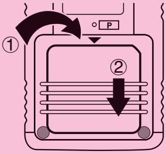
BEFORE USING THE CALCULATOR FOR THE FIRST TIME...

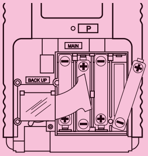
This calculator does not contain any main batteries when you purchase it. Be sure to perform the following procedure to load batteries, reset the calculator, and adjust the contrast before trying to use the calculator for the first time.

1. Remove the back cover from the calculator by pressing it in the direction indicated by arrow ①, and then sliding it in the direction indicated by arrow ②.

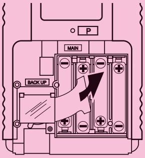


2. Load the four batteries that come with calculator.

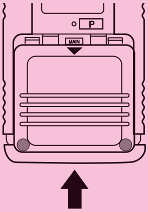
- Make sure that the positive (+) and negative (–) ends of the batteries are facing correctly.

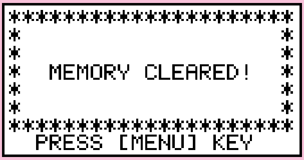


3. Remove the insulating sheet at the location marked “BACK UP” by pulling in the direction indicated by the arrow.



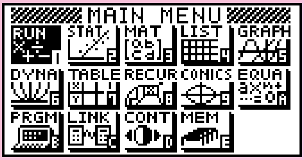
4. Replace the back cover onto the calculator and turn the calculator front side up, which should automatically turn on power and perform the memory reset operation.



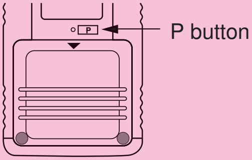


```
*********************
*                   *
*                   *
*  MEMORY CLEARED!  *
*                   *
*                   *
*********************
  PRESS [MENU] KEY
```

5. Press **MENU** .

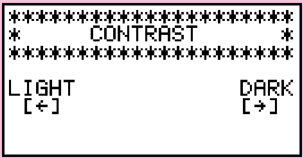


If the Main Menu shown to the right is not on the display, press the P button on the back of the calculator to perform memory reset.



6. Use the cursor keys (▲, ▼, ◀, ▶) to select the **CONT** icon and press **EXE**

or simply press D **sin** to display the contrast adjustment screen.



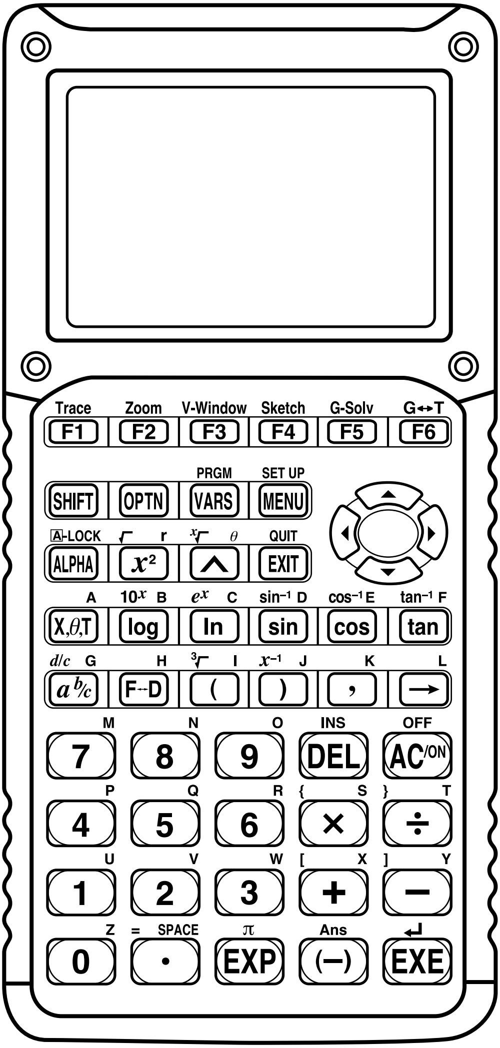
```
*********************
*     CONTRAST      *
*********************

LIGHT           DARK
 [←]             [→]
```

7. Use ◀ and ▶ to adjust contrast.

- ◀ makes figures on the screen lighter, while ▶ makes them darker.
- Holding down ◀ or ▶ changes the contrast setting at high speed.

8. After adjusting the contrast, press **MENU** to return to the Main Menu.

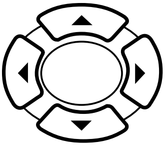
KEYS



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	146	Zoom F2	151	V-Window F3	129	Sketch F4	174	G-Solv F5	164	G↔T F6	136
SHIFT	2	OPTN	31	PRGM VARS	333 33	SET UP MENU	4 3				
A-LOCK ALPHA	2	√ r x^2	57 57	$^x\sqrt{}$ θ ^	56 56	QUIT EXIT					
A X,θ,T		10^x B log	56 56	e^x C ln	56 56	$\sin^{-1}$ D sin	55 55	$\cos^{-1}$ E cos	55 55	$\tan^{-1}$ F tan	55 55
d/c G $a\,^b/_c$	59 59	H F↔D		$^3\sqrt{}$ I (	57 46	x^{-1} J)	57 46	K ,		L →	25

	Page		Page		Page		Page		Page
M 7		N 8		O 9		INS DEL	24 23	OFF AC/ON	
P 4		Q 5		R 6		{ S ×	46	} T ÷	46
U 1		V 2		W 3		[X +	46	] Y −	46
Z 0		= SPACE .		π EXP	55 46	Ans (−)	49 46	↵ EXE	

Quick-Start

Quick-Start

Welcome to the world of graphing calculators and the CASIO fx-9750G.

Quick-Start is not a complete tutorial, but it takes you through many of the most common functions, from turning the power on to graphing complex equations. When you're done, you'll have mastered the basic operation of the fx-9750G and will be ready to proceed with the rest of this manual 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.

SWITCHING POWER ON AND OFF

To switch power on, press AC/ON.

To switch power off, press SHIFT AC/ON (OFF).

AUTO POWER OFF FUNCTION

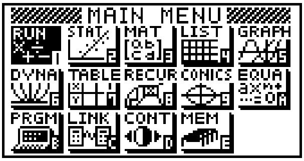
Note that the unit automatically switches power off if you do not perform any operation for about six minutes (about 60 minutes when a calculation is stopped by an output command (◢)).

USING MODES

The fx-9750G 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.

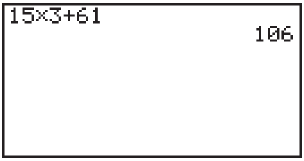
```
_
```

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.

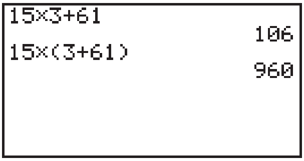


```
15×3+61
                106
```

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 fx-9750G includes a number of built-in scientific functions, including trigonometric and logarithmic functions.

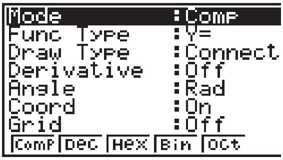
Example: 25 × sin 45˚

Important!

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

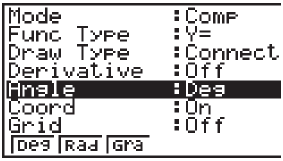
1. Press **AC/ON** .

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
```

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

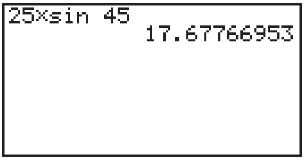


```
Mode          :Comp
Func Type     :Y=
Draw Type     :Connect
Derivative    :Off
Angle         :Deg
Coord         :On
Grid          :Off
```

4. Press **EXIT** to clear the menu.

5. Press **AC/ON** to clear the unit.

6. Press **2** **5** **×** **sin** **4** **5** **EXE** .



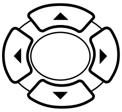
```
25×sin 45
              17.67766953
```

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˚)

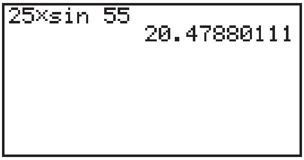
1. Press ◀ to display the last calculation.



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

3. Press **5** .

4. Press **EXE** to execute the calculation again.



```
25×sin 55
              20.47880111
```

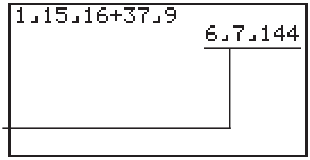
FRACTION CALCULATIONS

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 .



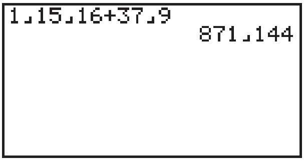
```
1⌟15⌟16+37⌟9
            6⌟7⌟144
```

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

Converting a Mixed Fraction to an Improper Fraction

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

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

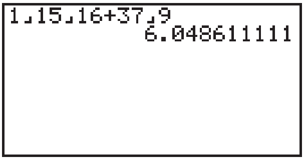


```
1⌟15⌟16+37⌟9
            871⌟144
```

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.

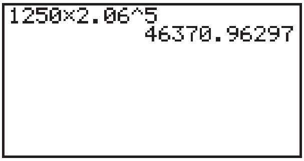


```
1⌟15⌟16+37⌟9
        6.048611111
```

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
```

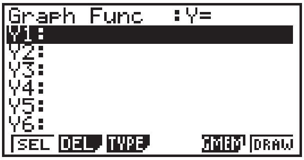
GRAPH FUNCTIONS

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)

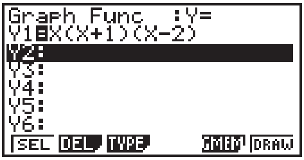
1. Press MENU .

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



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

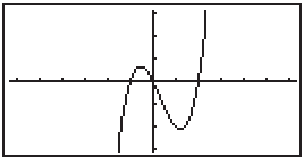
3. Input the formula.
   X,θ,T (X,θ,T + 1)
   (X,θ,T − 2) EXE



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

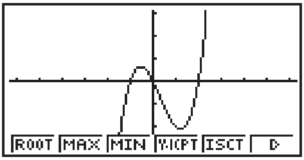
F6

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



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

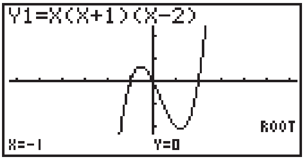
1. Press SHIFT F5 (G-Solv).



F1

2. Press F1 (ROOT).

   Press ▶ for other roots.

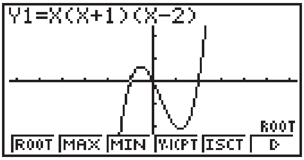


Y1=X(X+1)(X-2)

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)

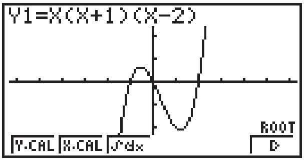
1. Press SHIFT F5 (G-Solv).



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

F6

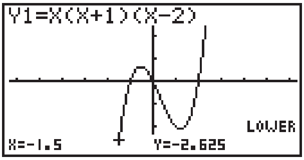
2. Press F6 (▷).



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

F3

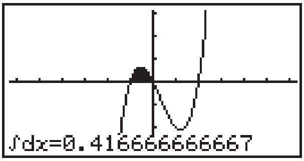
3. Press F3 (∫*dx*).



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

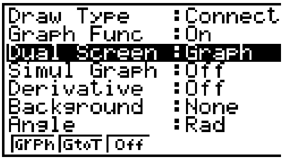
DUAL GRAPH

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

$$Y1 = X(X + 1)(X - 2)$$
$$Y2 = X + 1.2$$

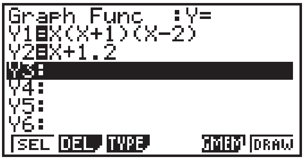
1. Press SHIFT SET UP ▼ ▼ F1 (Grph) to specify "Graph" for the Dual Screen setting.



```
Draw Type    :Connect
Graph Func   :On
Dual Screen  :Graph
Simul Graph  :Off
Derivative   :Off
Background   :None
Angle        :Rad
```

F1

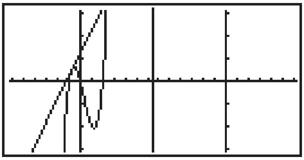
2. Press EXIT , and then input the two functions.
   X,θ,T (X,θ,T + 1)
   (X,θ,T − 2) EXE
   X,θ,T + 1 • 2 EXE



```
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.

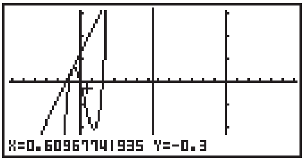


BOX ZOOM

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

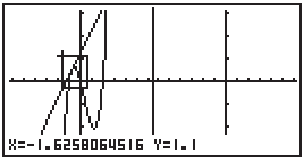
1. Press SHIFT F2 (Zoom) F1 (BOX).

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



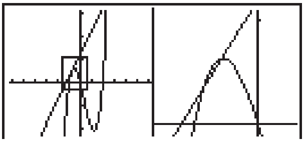
```
X=0.60967741935 Y=-0.3
```

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

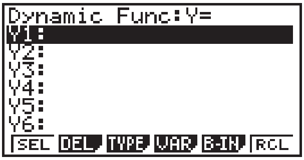
Dynamic Graph lets you see how the shape of a graph is affected as the value assigned to one of the coefficients of its function changes.

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.

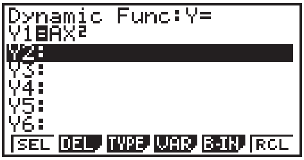
2. Use ◀, ▶, ▲, and ▼ to highlight **DYNA**, and then press EXE.



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:

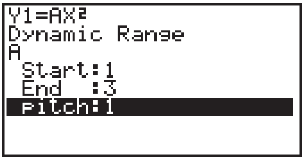
F4

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

Y1=AX²
Dynamic Var :A
A=1

F2

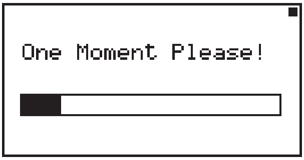
5. Press F2 (RANG) 1 EXE 3 EXE 1 EXE to specify the range and increment of change in coefficient A.



Y1=AX²
Dynamic Range
A
Start:1
End :3
Pitch:1

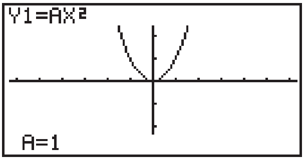
6. Press EXIT.

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

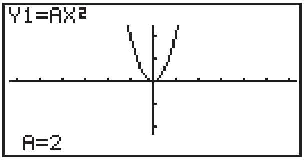


One Moment Please!

↓



↓↑



↓↑

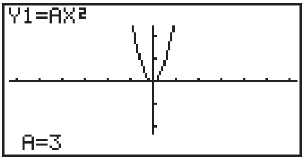


TABLE FUNCTION

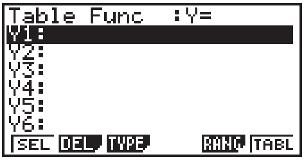
The Table Function makes it possible to generate a table of solutions as different values are assigned to the variables of a function.

Example: To create a number table for the following function

Y = X (X+1) (X–2)

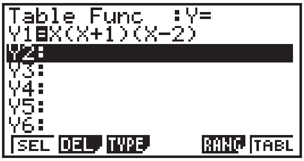
1. Press MENU .

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



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

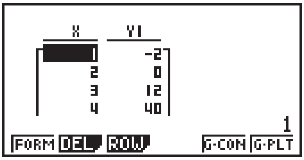
3. Input the formula.
   X,θ,T (X,θ,T + 1)
   (X,θ,T − 2) EXE



```
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 fx-9750G.

To learn all about the many powerful features of the fx-9750G, 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.
- 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 All 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 manual 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.

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- No part of this manual may be reproduced in any form without the express written consent of the manufacturer.
- The options described in Chapter 20 of this manual may not be available in certain geographic areas. For full details on availability in your area, contact your nearest CASIO dealer or distributor.

fx-9750G

Contents

Chapter 2 Manual Calculations 45

Chapter 3 Solve, Differential/Quadratic Differential, Integration, Maximum/Minimum Value, and Σ Calculations 63

Chapter 4 Complex Numbers 79

Chapter 5 Binary, Octal, Decimal, and Hexadecimal Calculations 85

Chapter 6 Matrix Calculations 91

Chapter 9 Graph Solve 163

Chapter 10 Sketch Function 173

Chapter 11 Dual Graph 189

Chapter 12 Graph-to-Table 201

Chapter 13 Dynamic Graph 207

Chapter 14 Implicit Function Graphs 223

Chapter 18 Statistical Graphs and Calculations 283

Chapter 19 Programming 313

Chapter 20 Data Communications 363

Chapter 21 Program Library 375

Appendix 393

Getting Acquainted
— Read This First!

The symbols in this manual indicate the following messages.

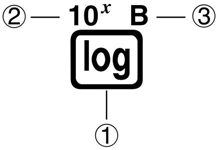
: Important notes

: Notes

P.000 : Reference pages

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.

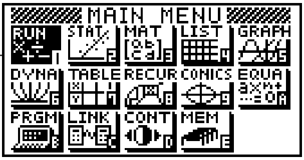
2. Selecting Icons and Entering Modes

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.

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	Meaning
RUN 1	Use this mode for arithmetic calculations and function calculations, and for calculations involving binary, octal, decimal and hexadecimal values.
STAT 2	Use this mode to perform single-variable (standard deviation) and paired-variable (regression) statistical calculations, and to draw statistical graphs.
MAT 3	Use this mode for storing and editing matrices.
LIST 4	Use this mode for storing and editing numeric data.
GRAPH 5	Use this mode to store graph functions and to draw graphs using the functions.
DYNA 6	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	Meaning
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	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	Use this mode to draw graphs of implicit functions.
EQUA	Use this mode to solve linear equations with two through six unknowns, quadratic equations, and cubic equations.
PRGM	Use this mode to store programs in the program area and to run programs.
LINK	Use this mode to transfer memory contents or back-up data to another unit.
CONT	Use this mode to adjust the contrast of the display.
MEM	Use this mode to check how much memory is used and remaining, to delete data from memory, and to initialize (reset) the calculator.

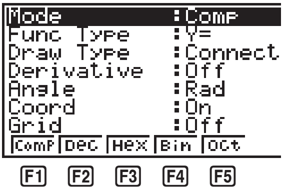
■ Using the Set Up Screen

The first thing that appears when you enter a mode is the mode's set up screen, which shows the current status of settings for the mode. 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.



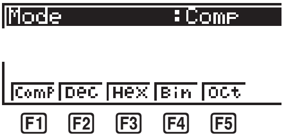
```
Mode         :Comp
Func Type    :Y=
Draw Type    :Connect
Derivative   :Off
Angle        :Rad
Coord        :On
Grid         :Off
```

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.

•Calculation/Binary, Octal, Decimal, Hexadecimal Setting Mode (Mode)



Mode :Comp

F1 (Comp) ..... General Arithmetic Calculation Mode

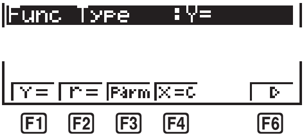
F2 (Dec) .... Specifies decimal values as default

F3 (Hex) .... Specifies hexadecimal values as default

F4 (Bin) .... Specifies binary values as default

F5 (Oct) .... Specifies octal values as default

•Graph Function Type (Func Type)



Func Type :Y=

F1 (Y=) .... Rectangular coordinate graphs

F2 (r=) .... Polar coordinate graphs

F3 (Parm) ...... Parametric coordinate graphs

F4 (X=c) .... Graphs in which value of X is constant

F6 (▷) .... Next menu

Func Type :Y=

F1 (Y>) .... $y > f(x)$ inequality graph

F2 (Y<) .... $y < f(x)$ inequality graph

F3 (Y≥) .... $y \geqq f(x)$ inequality graph

F4 (Y≤) .... $y \leqq f(x)$ inequality graph

F6 (▷) .... Previous menu

- The setting you make for Func Type determines the variable name that is input when you press X,θ,T.

•Graph Draw Type (Draw Type)

F1 (Con) .... Connection of points plotted on graph.

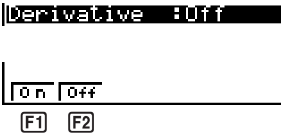
F2 (Plot) .... Plotting of points on graph without connection.


Draw Type :Connect

•Derivative Display Mode (Derivative)

F1 (On) .... Turns on display of derivative value when using Graph-to-Table, Table & Graph, and Trace.

F2 (Off) .... Turns off display of derivative value.


Derivative :Off

•Angle Unit (Angle)

F1 (Deg) .... Specifies degrees as default.

F2 (Rad) .... Specifies radians as default.

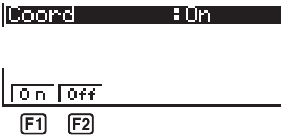
F3 (Gra) .... Specifies grads as default.


Angle :Rad

•Graph Pointer Coordinates (Coord)

F1 (On) .... Turns on display of coordinates of current graph screen pointer location.

F2 (Off) .... Turns off display of coordinates of current graph screen pointer location.


Coord :On

P.136

•Graph Gridlines (Grid)

F1 (On) .... Turns on display of graph screen gridlines.

F2 (Off) .... Turns off display of graph screen gridlines.


Grid :Off

•Graph Axes (Axes)

P.136

F1 (On) .... Turns on display of graph screen axes.

F2 (Off) .... Turns off display of graph screen axes.

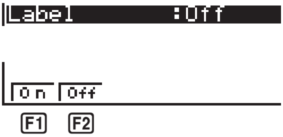

Axes :On

P.136

•Graph Axis Labels (Label)

F1 (On) .... Turns on display of graph screen axis labels.

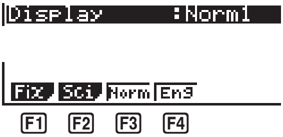
F2 (Off) .... Turns off display of graph screen axis labels.


Label :Off

•Display Format (Display)

F1 (Fix) .... Displays screen for specification of number of decimal places.

F2 (Sci) .... Displays screen for specification of number of significant digits.


Display :Norm1

P.18

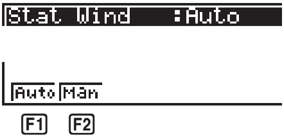
F3 (Norm) ...... Switches exponential format display range.

F4 (Eng) .... Engineering mode.

•Statistical Graph View Window Setting (Stat Wind)

F1 (Auto) .... Automatic setting of view window values for statistical graph drawing.

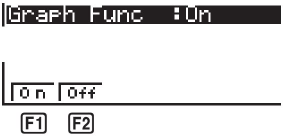
F2 (Man) .... Manual setting of view window values for statistical graph drawing.


Stat Wind :Auto

•Graph Function Display (Graph Func)

F1 (On) .... Turns on display of function during graph drawing and trace.

F2 (Off) .... Turns off display of function during graph drawing and trace.


Graph Func :On

P.161

•Graph Background (Background)

F1 (None) ...... No graph background.

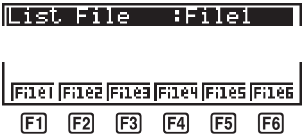
F2 (PICT) ...... Displays screen for specification of picture for graph background.


Background :None

P.282

•List File Specification (List File)

F1(File 1)~
F6(File 6) .... List file number (1 to 6) specification.



List File :File1

•Dual Screen Mode (Dual Screen)

The Dual Screen Mode setting you can select differs depending upon whether you are using the GRAPH Mode set up screen or the TABLE/RECUR Mode set up screen.

P.190

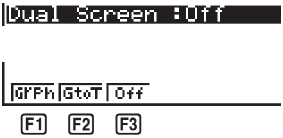
GRAPH Mode

F1 (Grph) ...... Divides screen into two parts, each of which can be used for graphing.

P.202

F2 (GtoT) ...... Divides screen into two parts for generation of numeric table from graph.

F3 (Off) .... Dual Screen off.



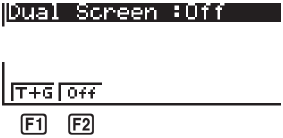
Dual Screen :Off

P.247

TABLE/RECUR Mode

F1 (T+G) .... Divides screen into two parts, one for graphing and one for a numeric table.

F2 (Off) .... Dual Screen off.

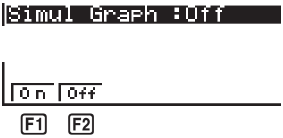


Dual Screen :Off

•Simultaneous Graph Mode (Simul Graph)

F1 (On) .... Turns on simultaneous graphing of all functions in memory.

F2 (Off) .... Simultaneous graphing off (graphs drawn one-by-one).



Simul Graph :Off

P.215

•Dynamic Graph Type (Dynamic Type)

F1 (Cnt) .... Continuous drawing of Dynamic Graphs.

F2 (Stop) .... Automatic stopping of Dynamic Graph drawing after 10 draws.

Dynamic Type:Stop

•Table & Graph Generation Settings (Variable)

P.238	F1 (Rang)	Table generation and graph drawing using numeric table range.
P.238	F2 (LIST)	Table generation and graph drawing using list data.


Variable :Range

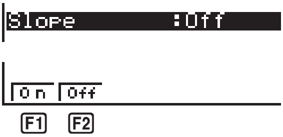
•Σ Data Display Mode (Σ Display)

F1 (On)	Turns on display of Σ value on recursion numeric table.
F2 (Off)	Turns off display of Σ value.


Σ Display :Off

•Implicit Function Graph Derivative Display Mode (Slope)

F1 (On)	Turns on display of derivative at current pointer location on implicit function graph screen.
F2 (Off)	Turns off display of derivative.


Slope :Off

Abbreviations

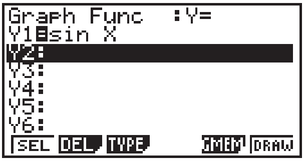
STAT	Statistics
MAT	Matrix
DYNA	Dynamic Graph
RECUR	Recursion
EQUA	Equation
PRGM	Program
CONT	Contrast
MEM	Memory

3. Display

About the Display Screen

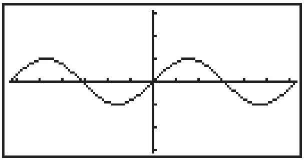
This calculator uses two types of display: a text display and a graphic display. The text display can show 21 columns and eight lines of characters, with the bottom line used for the function key menu, while the graph display uses an area that measures 127 (W) × 63 (H) dots.

Text Display



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

Graph Display



About 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

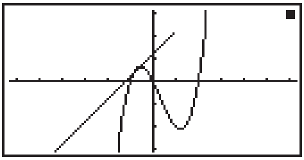
```
12.58244
            12°34’56.78”
```

..... 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 Screen

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.

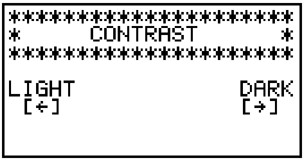


4. Contrast Adjustment

Adjust the contrast whenever objects on the display appear dim or difficult to see.

•To display the contrast adjustment screen

Highlight the **CONT** icon in the Main Menu and then press EXE.



```
*********************
*     CONTRAST      *
*********************

LIGHT            DARK
 [←]             [→]
```

Use ◀ and ▶ to adjust contrast.

- ◀ makes figures on the screen lighter, while ▶ makes them darker.
- Holding down ◀ or ▶ changes the contrast setting at high speed.

After adjusting the contrast, press MENU to return to the Main Menu.

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

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.

P.3

In Case of Hang Up

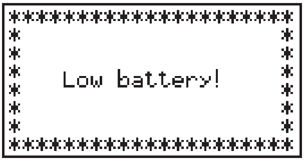
P.395

- 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

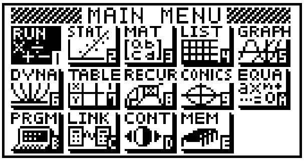
The low battery message appears while the main battery power is below a certain level whenever you press AC/ON to turn power on or MENU to display the Main Menu.

AC/ON or MENU



Low battery!

↓ *About 3 seconds later*



P.396

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”.

   F1 (Deg) .... Specifies degrees as default.

   F2 (Rad) .... Specifies radians as default.

   F3 (Gra) .... Specifies grads as default.

Angle :Rad

2. Press the function key that corresponds to the angle unit you want to use.

- 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)

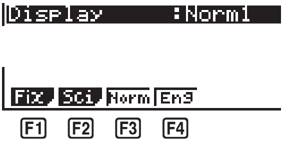
1. Display the Set Up Screen and use the ▲ and ▼ keys to highlight “Display”.

   F1 (Fix) .... Displays screen for specification of number of decimal places.

   F2 (Sci) .... Displays screen for specification of number of significant digits.

   F3 (Norm) ..... Switches exponential format display range.

   F4 (Eng) .... Displays calculation results using engineering notation.



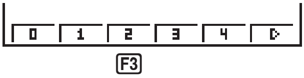
Display :Norm1

2. Press the function key that corresponds to the display format you want to use.

• To specify the number of decimal places (Fix)

Example **To specify two decimal places.**

F1 (Fix)



F3 (2)


Display :Fix2

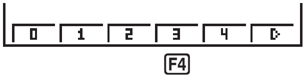
Press the function key that corresponds to the number of decimal places you want to specify (n = 0 ~ 9).

- 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)


Display :Sci3

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

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

- 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 **$2(5 + 4) \div (23 \times 5) =$**

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

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

$\hat{}(x^y)$, $^x\sqrt{\ }$

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.

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

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

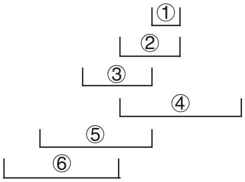
⑬ Or, or, xor, xnor

- When functions with the same priority are used in series, execution is performed from right to left.

  $e^x\ln\sqrt{120} \to e^x\{\ln(\sqrt{120})\}$

  Otherwise, execution is from left to right.
- 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.

- Before the Type B functions

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

- Before constants, variable names, memory

Example **2π, 2AB, 3Ans, 3Y$_1$, etc.**

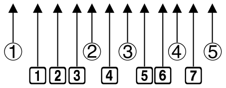
- Before an open parenthesis

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*. If you execute a formula so complex it exceeds the amount of stack space available, an error message appears on the display (Stk ERROR during calculations or Ne ERROR during execution of a program subroutine).

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



Numeric Value Stack

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

Command Stack

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

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

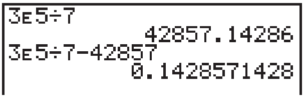
P.22

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 × 10^5 ÷ 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.401 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).

P.399

- 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.50 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(, PxIOn, 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.

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 a space 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 switch power off.

•To assign a value to a variable

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 **MEM** 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

P.31

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.

•To display the Function Memory Menu

OPTN F6(▷) F6(▷) F3(FMEM)

F1(STO) .... Stores functions
F2(RCL) .... Recalls functions
F3(f*n*) .... Specifies input as a function.
F4(SEE) .... Displays a list of stored functions

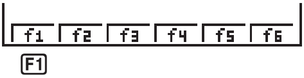
•To store a function

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

F2 (RCL)

F1

F1 (f_1)

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

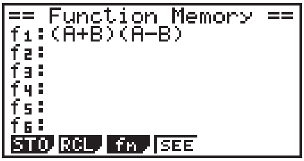
- The recalled function appears at the current location of the cursor on the display.

●To display a list of available functions

OPTN F6 (▷) F6 (▷) F3 (FMEM)

F4

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

F1 (STO)

F1

F1 (f_1)

```
== 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 (f_1)(stores (x^3 + 1))

AC X,θ,T x^2 + X,θ,T

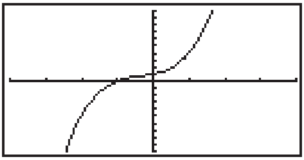
F1 (STO) F2 (f_2)(stores (x^2 + x))

AC SHIFT F4 (Sketch) F1 (Cls) EXE

SHIFT F4 (Sketch) F5 (GRPH) F1 (Y=)

OPTN F6 (▷) F6 (▷) F3 (FMEM)

F3 (f_n) F1 (f_1) + F2 (f_2) EXE



P.125

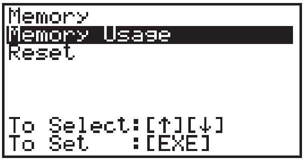
- For full details about graphing, see “8. Graphing”.

■ Memory Status (MEM)

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.

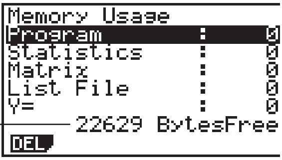
•To check the memory status

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



```
Memory
Memory Usage
Reset


To Select:[↑][↓]
To Set   :[EXE]
```

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



```
Memory Usage
Program        :    0
Statistics     :    0
Matrix         :    0
List File      :    0
Y=             :    0
    22629 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

Clearing Memory Contents

You have a choice of two differenct procedures that you can use to clear memory contents.

- Clearing specific data within a selected data type
- Clearing all data within a specific data type

•To clear specific data within a selected data type

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

2. Press F1 (DEL). If you selected a data type that contains multiple memory areas, a function menu like the one shown below appears to let you specify which memory you want to clear.

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

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

4. Press F1 (YES) to clear the data or F6 (NO) to abort the operation without clearing anything.

•To clear all data within a specific data type

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

2. Press F1 (DEL). The following confirmation menu appears if you selected a data type in which all data can be cleared by a single operation.

3. Press F1 (YES) to clear the data or F6 (NO) to abort the operation without clearing anything.

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.

•Option Menu in the RUN and PRGM Modes

OPTN

P.263 F1 (LIST) .... List function menu

P.101 F2 (MAT) .... Matrix operation menu

P.80 F3 (CPLX) ..... Complex number calculation menu

F4 (CALC) ..... Functional analysis menu

P.307 F5 (STAT) ...... Paired-variable statistical estimated value menu

F6 (▷) .... Next menu

F6 (▷)

P.56 F2 (HYP) .... Hyperbolic calculation menu

P.52 F3 (PROB) .... Probability/distribution calculation menu

P.53 F4 (NUM) ...... Numeric calculation menu

P.53 F5 (ANGL) ..... Menu for angle/coordinate conversion, sexagesimal input/conversion

F6 (▷) .... Next menu

F6 (▷)

P.54 F1 (ESYM) .... Engineering symbol menu

P.159 F2 (PICT) ...... Graph save/recall menu

P.26 F3 (FMEM) .... Function memory menu

P.61 F4 (LOGIC) ... Logic operator menu

F6 (▷) .... Previous menu

Note that the OPTN key is disabled while binary, octal, decimal, or hexadecimal is set as the default number system.

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

OPTN

F6(▷)

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

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

OPTN

F6(▷)

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

1-4 Variable Data (VARS) Menu

You can use the variable data menu to recall the data listed below.

- View Window values
- Enlargement/reduction factor
- Single-variable/paired-variable statistical data
- Graph functions
- Dynamic Graph set up data
- Table & Graph table range and table contents
- Recursion formula, table range, and table contents
- Equation coefficients and solutions

The variable data menu does not appear if you press VARS while binary, octal, decimal, or hexadecimal is set as the default number system.

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

VARS

F1 F2 F3 F4 F5 F6

F1 (V-WIN) .... View Window values

F2 (FACT) ..... x and y-axis enlargement/reduction factor

F3 (STAT) ...... Single/paired-variable statistical data

P.36 F4 (GRPH) .... Graph functions stored in the GRAPH Mode

P.37 F5 (DYNA) .... Dynamic Graph set up data

F6 (▷) .... Next menu

F6 (▷)

F1 F2 F3 F6

P.38 F1 (TABL) ...... Table & Graph function table range and table contents

P.38 F2 (RECR) .... Recursion formula table range and table contents

P.40 F3 (EQUA) .... Solutions and coefficients of linear equations with two through six unknowns, quadratic equations, and cubic equations

F6 (▷) .... Previous menu

- Note that the EQUA item appears for function key F3 only when you access the variable data menu from the **RUN** or **PRGM** Mode.

P.127

•To recall View Window values

Pressing F1 (V-WIN) while the variable data menu is on the screen displays a View Window value menu.

F1 (V-WIN)

F1 (X) .... x-axis menu
F2 (Y) .... y-axis menu
F3 (T,θ) .... T,θ menu
F4 (R-X) .... x-axis menu for Dual Graph right hand screen
F5 (R-Y) .... y-axis menu for Dual Graph right hand screen
F6 (R-T,θ) ...... T,θ menu for Dual Graph right hand screen

The following menu appears whenever you press F1 (X), F2 (Y), F4 (R-X), or F5 (R-Y) while the View Window value menu is on the display.

F1 (min)......... Minimum
F2 (max) .... Maximum
F3 (scal) .... Scale

The following menu appears whenever you press F3 (T,θ) or F6 (R-T,θ) while the view window value menu is on the display.

F1 (min)......... Minimum
F2 (max) .... Maximum
F3 (ptch) .... Pitch

P.153

•To recall enlargement and reduction factors

Pressing F2 (FACT) while the variable data menu is on the screen displays an enlargement/reduction factor menu.

F2(FACT)

F1 (Xfct) .... x-axis enlargement/reduction factor
F2 (Yfct) .... y-axis enlargement/reduction factor

•To recall single/paired-variable statistical data

Pressing F3 (STAT) while the variable data menu is on the screen displays a statistical data menu.

F3(STAT)

F1 (X) .... Single/paired-variable x-data menu

F2 (Y) .... Paired-variable y-data menu

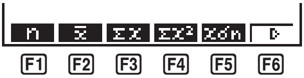
F3 (GRPH) .... Statistical graph data menu

F4 (PTS) .... Summary point data menu

P.296

The following menu appears whenever you press F1 (X), while the statistical data menu is on the display.

F1 (X)



F1 (n) .... Number of data

F2 ($\bar{x}$)............. Mean of x data

F3 (Σx) .... Sum of x data

F4 (Σx^2) .... x data sum of squares

F5 ($x\sigma_n$) .... x data population standard deviation

F6 (▷) .... Next menu

F6 (▷)

F1 ($x\sigma_{n\text{-}1}$) .... x data sample standard deviation

F2 (minX) ...... x data minimum value

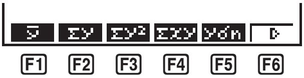
F3 (maxX) ..... x data maximum value

F6 (▷) .... Previous menu

P.301

The following menu appears whenever you press F2 (Y) while the statistical data menu is on the display.

F2 (Y)



F1 ($\bar{y}$)............. Mean of y data

F2 (Σy) .... Sum of y data

F3 (Σy^2) .... y data sum of squares

F4 (Σxy)......... x data and y data sum of products

F5 ($y\sigma_n$) .... y data population standard deviation

F6 (▷) .... Next menu

F6 (▷)

F1 ($y\sigma_{n-1}$) .... y data sample standard deviation

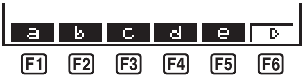
F2 (minY) ...... y data minimum value

F3 (maxY) ..... y data maximum value

F6 (▷) .... Previous menu

The following menu appears whenever you press F3 (GRPH) while the statistical data menu is on the display.

F3 (GRPH)



F1 (a)-F5 (e) .. Statistical graph regression coefficient and multinomial coefficients

F6 (▷) .... Next menu

F6 (▷)

P.301

F1 (r) .... Statistical graph correlation coefficient

F2 (Q1) .... First quartile

F3 (Med) .... Median of input data

F4 (Q3) .... Third quartile

F5 (Mod) .... Mode of input data

F6 (▷) .... Previous menu

The following menu appears whenever you press F4 (PTS) while the statistical data menu is on the display.

F4 (PTS)

F1 ($x1$) ~ F6 ($y3$) .... Coordinates of summary points

P.132

•To recall graph functions

Pressing F4 (GRPH) while the variable data menu is on the screen displays a graph function menu.

F4 (GRPH)

Input a storage area number and then press one of the following function keys to recall the corresponding graph function stored in that storage area.

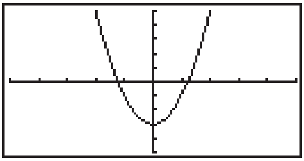
F1 (Y) .... Rectangular coordinate or inequality function
F2 (*r*) .... Polar coordinate function
F3 (Xt) .... Parametric graph function Xt
F4 (Yt) .... Parametric graph function Yt
F5 (X) .... X=constant graph function

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



P.211

•To recall Dynamic Graph set up data

Pressing F5 (DYNA) while the variable data menu is on the screen displays a Dynamic Graph set up menu.

F5 (DYNA)

F1 (Strt) .... Coefficient range start value
F2 (End) .... Coefficient range end value
F3 (Pitch) ...... Coefficient value increment

•To recall Table & Graph table range and table content data

Pressing F6 (▷) and then F1 (TABL) while the variable data menu is on the screen displays a Table & Graph data menu.

F6 (▷)F1 (TABL)

P.237

F1 (Strt)	Table range start value (F Start command)
F2 (End)	Table range end value (F End command)
F3 (Pitch)	Table value increment (F pitch command)
F4 (Reslt)	Matrix of table contents (F Result command)

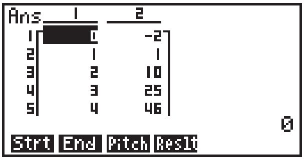
- The Reslt item appears for function key F4 only when the above menu is displayed in the **RUN** or **PRGM** Mode.

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)

```
F Result
```

EXE



```
Ans    1      2
  1[   0     -2]
  2    1      1
  3    2     10
  4    3     25
  5    4     46
                     0
Strt End Pitch Reslt
```

•To recall recursion formula, table range and table content data

Pressing F6 (▷) and then F2 (RECR) while the variable data menu is on the screen displays a recursion data menu.

F6 (▷)F2 (RECR)

F1 (FORM)	Recursion formula data menu
F2 (RANG)	Table range data menu
F3 (Reslt)	Matrix of table contents (R Result command)

To recall recursion formula data

The following menu appears whenever you press F1 (FORM) while the recursion data menu is on the display.

P.250

F1 (FORM)

F1 (a_n) .... a_n expression
F2 (a_{n+1}) .... a_{n+1} expression
F3 (a_{n+2}) .... a_{n+2} expression
F4 (b_n) .... b_n expression
F5 (b_{n+1}) .... b_{n+1} expression
F6 (b_{n+2}) .... b_{n+2} expression

To recall table range data

The following menu appears whenever you press F2 (RANG) while the recursion data menu is on the display.

P.251

F2 (RANG)

F1 (Strt) .... Table range start value (F Start command)
F2 (End) .... Table range end value (F End command)
F3 (a_0) .... Zero term a_0 value
F4 (a_1) .... First term a_1 value
F5 (a_2) .... Second term a_2 value
F6 (▷) .... Next menu

F6 (▷)

F1 (b_0) .... Zero term b_0 value
F2 (b_1) .... First term b_1 value
F3 (b_2) .... Second term b_2 value
F4 (a_nSt) .... Origin of a_n recursion formula convergence/divergence graph (WEB graph)
F5 (b_nSt) .... Origin of b_n recursion formula convergence/divergence graph (WEB graph)
F6 (▷) .... Previous menu

To recall matrix of table contents

Whenever you press F3 (Reslt) while the recursion data menu is on the display, the recursion formula numeric table appears on the screen in matrix format.

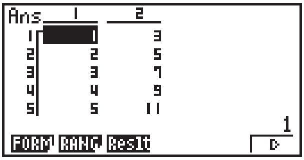
- This operation is available only from the **RUN** or **PRGM** Mode.

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)

```
R Result
```

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 (Dim ERROR) occurs if you perform the above operation when there is no function or recursion formula numeric table in memory.

•To recall equation coefficients and solutions

Pressing F6 (▷) and then F3 (EQUA) while the variable data menu is on the screen displays an equation data menu.

P.117

F6(▷)F3(EQUA)

F1 F2 F3 F4

P.120

F1 (S-Rlt) ...... Matrix of solutions for linear equations with two through six unknowns

F2 (S-Cof) ..... Matrix of coefficients for linear equations with two through six unknowns

F3 (P-Rlt) ...... Matrix of solutions for a quadratic or cubic equation

F4 (P-Cof) ..... Matrix of 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)

```
Sim Result _
```

EXE

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

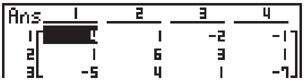
Example 2 To recall the coefficients for the following linear equations with three unknowns

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

F2(S-Cof)

```
Sim Coef _
```

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)

```
Ply Result
```

EXE

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

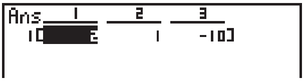
Example 4 To recall the coefficients for the following quadratic equation

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

F4(P-Cof)

```
Ply Coef _
```

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 (Mem ERROR) to be generated.

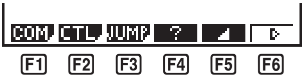
  When there are no coefficients input for the equation

  When there are no solutions obtained for the equation

1-5 Program (PRGM) Menu

To display the program menu, first enter the **RUN** or **PRGM** Mode from the Main Menu, and then press SHIFT PRGM.

SHIFT PRGM



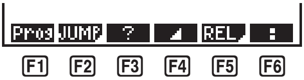
F1 (COM) ...... Program command menu
F2 (CTL) .... Program control command menu
F3 (JUMP) ..... Jump command menu
F4 (?) .... Input command
F5 (◢) .... Output command
F6 (▷) .... Next menu

F6 (▷)

F1 (CLR) .... Clear command menu
F2 (DISP) ...... Display command menu
F3 (REL) .... Conditional jump relational operator menu
F4 (I/O) .... Input/output control command menu
F5 (:) .... Multistatement connector
F6 (▷) .... Previous menu

The following 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.

SHIFT PRGM



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

P.313

For details on the commands that are available in the various menus you can access from the program menu, see “19. 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**
$\dfrac{6}{4 \times 5} = 0.3$	**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] The final closed parentheses (immediately before operation of the EXE key) may be omitted, no matter how many are required.

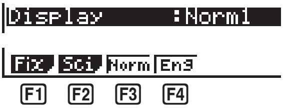
[*3] A multiplication sign immediately before an open parenthesis may be omitted.

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

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

P.7

- These settings can be made while setting up the display format (Display) with the set up screen.


Display :Norml

P.53

- 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.
- Number of decimal place and number of significant digit settings remain in effect until you change them or until you change the exponential display range (Norm) setting.
- 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 SET UP ▼▼▼▼▼▼▼▼▼ F1 (Fix) F5 (4) EXIT EXE	**16.6667**[*1]
5 significant digits	SHIFT SET UP ▼▼▼▼▼▼▼▼▼ F2 (Sci) F6 (▷) F1 (5) EXIT EXE	**1.6667E+01**[*1]
Cancels specification	SHIFT SET UP ▼▼▼▼▼▼▼▼▼ 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 SET UP ▼▼▼▼▼▼▼▼▼ 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:

	200 ÷ **7** EXE	**28.571**
The value stored internally is cut off to the number of decimal places you specify.	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 recall the contents of the answer memory

SHIFT Ans EXE

•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

```
123+456
                579
```

7 8 9 − SHIFT Ans EXE

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

- The largest value that the answer memory can hold 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 =

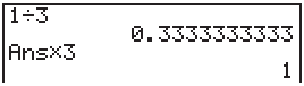
1 ÷ 3 × 3 =

AC 1 ÷ 3 EXE

```
1÷3
       0.3333333333
```

(Continuing)

× 3 EXE



```
1÷3
       0.3333333333
Ans×3
                  1
```

P.19

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**

$4.12 \times \underline{6.4} = 26.368$

$4.12 \times \underline{7.1} = 29.252$

AC 4 • 1 2 × 6 • 4 EXE

```
4.12×6.4
                    26.368
```

◀ ◀ ◀ ◀

```
4.12×6.4
```

7 • 1

```
4.12×7.1_
```

EXE

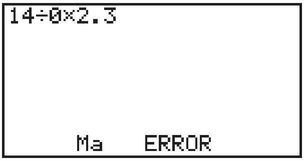
```
4.12×7.1
                    29.252
```

- 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.

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
                3.22
```

■ 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.

•To use multistatements

Example **6.9 × 123 = 848.7**

123 ÷ 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 × 456: × 5**

Invalid

2-3 Function Calculations

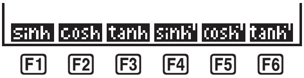
Function Menus

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 F6 (▷) F2 (HYP)



F1 (sinh) .... Hyperbolic sine
F2 (cosh) .... Hyperbolic cosine
F3 (tanh) .... Hyperbolic tangent
F4 (sinh^{-1}) ...... Inverse hyperbolic sine
F5 (cosh^{-1}) ..... Inverse hyperbolic cosine
F6 (tanh^{-1}) ...... Inverse hyperbolic tangent

•Probability/Distribution Calculations (PROB)

OPTN F6 (▷) F3 (PROB)

F1 (x!) .... Input a value and select this item to obtain the factorial of the value.
F2 (nPr) .... Permutation
F3 (nCr) .... Combination
F4 (Ran#) ...... Pseudo random number in the range of 0 to 1 (10 decimal places).
F6 (▷) .... Next menu

F6 (▷)

P.309

F1 (P () .... Probability P (t)
F2 (Q () .... Probability Q (t)
F3 (R () .... Probability R (t)
F4 (t () .... Normalized variate t (x) value
F6 (▷) .... Previous menu

•Numeric Calculations (NUM)

OPTN F6(▷)F4(NUM)

F1 (Abs)	Select this item and input a value to obtain the absolute value of the value.
F2 (Int)	Select this item and input a value to extract the integer part of the value.
F3 (Frac)	Select this item and input a value to extract the fraction part of the value.
F4 (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.
F5 (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 F6(▷)F5(ANGL)

F1 (°)	Specifies degrees for a specific input value.
F2 (r)	Specifies radians for a specific input value.
F3 (g)	Specifies grads for a specific input value.
F4 (° ’ ”)	Specifies degrees (hours), minutes, seconds when inputting a sexagesimal value.
F5 ($\overleftarrow{°’”}$)	Converts decimal value to sexagesimal value.
F6 (▷)	Next menu

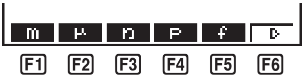
F6(▷)

F1 (Pol()	Rectangular-to-polar coordinate conversion
F2 (Rec()	Polar-to-rectangular coordinate conversion
F6 (▷)	Previous menu

- The $\overleftarrow{°’”}$ menu option appears only when there is a calculation result shown on the display.

•Engineering Notation Calculations (ESYM)

OPTN F6 (▷) F6 (▷) F1 (ESYM)



F1 (m) .... milli (10^{-3})

F2 (µ) .... micro (10^{-6})

F3 (n) .... nano (10^{-9})

F4 (p) .... pico (10^{-12})

F5 (f) .... femto (10^{-15})

F6 (▷) .... Next menu

F6 (▷)

F1 (k) .... kilo (10^{3})

F2 (M) .... mega (10^{6})

F3 (G) .... giga (10^{9})

F4 (T) .... tera (10^{12})

F5 (P) .... peta (10^{15})

F6 (▷) .... Next menu

F6 (▷)

F1 (E) .... exa (10^{18})

F2 (ENG) .... Shifts the decimal place of the displayed value three digits to the left and decreases its exponent by three. When you are using engineering notation, the engineering symbol is also changed accordingly (i.e. m → µ).

F3 ($\overleftarrow{\text{ENG}}$) .... Shifts the decimal place of the displayed value three digits to the right and increases its exponent by three. When you are using engineering notation, the engineering symbol is also changed accordingly (i.e. µ → m).

F6 (▷) .... Previous menu

- The ENG and $\overleftarrow{\text{ENG}}$ menu options appear only when there is a calculation result shown on the display.

Angle Units

P.53

- Once you specify an angle unit, it remains in effect until you specify a different one. The specification is retained even if you switch power off.

P.5

- Be sure to specify “Comp” for Calculation/Binary, Octal, Decimal, Hexadecimal Setting 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.6

- 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 Setting Mode.

Example	Operation	Display
sin 63° = 0.8910065242	SHIFT SET UP ▼ ▼ ▼ ▼ F1 (Deg) EXIT sin **63** EXE	**0.8910065242**
$\cos(\frac{\pi}{3}\text{rad}) = 0.5$	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**
$\text{cosec } 30° = \frac{1}{\sin 30°} = 2$	**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 Setting Mode.

Example	Operation	Display
log 1.23 ($\log_{10}1.23$) = 8.990511144 × 10^{-2}	log **1.23** EXE	**0.08990511144**
In 90 ($\log_e 90$) = 4.49980967	In **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 Setting 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 In 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

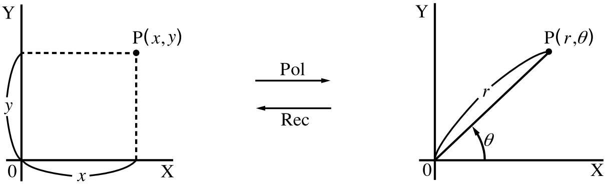
Other Functions

- Be sure to specify "Comp" for Calculation/Binary, Octal, Decimal, Hexadecimal Setting 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 $\frac{3}{4}$? $\left\vert \log \frac{3}{4} \right\vert = 0.1249387366$	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 Setting Mode.

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

Operation	Display
SHIFT SETUP ▼ ▼ ▼ ▼ F1 (Deg) EXIT OPTN F6 (▷) F5 (ANGL) F6 (▷) F1 (Pol( ) **14** , **20.7**) EXE	Ans 1 ⌈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 SETUP ▼ ▼ ▼ ▼ F1 (Deg) EXIT OPTN F6 (▷) F5 (ANGL) F6 (▷) F2 (Rec( ) **25** , **56**) EXE	Ans 1 ⌈13.979⌉ → 13.97982259 (x) 2 ⌊20.725⌋ → 20.72593931 (y)

Permutation and Combination

- **Permutation**

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

- **Combination**

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

P.5

- Be sure to specify "Comp" for Calculation/Binary, Octal, Decimal, Hexadecimal Setting 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 Setting 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**
$\frac{1}{2578}+\frac{1}{4572}$ $=6.066202547\times10^{-4}$	**1** a b/c **2578** + **1** a b/c **4572** EXE	**6.066202547E–04***2 (Norm 1 display format)
$\frac{1}{2}\times0.5=0.25$	**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 deliminater 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.

P.16
P.5

■ Engineering Notation Calculations

Input engineering symbols using the engineering notation menu.

- Be sure to specify “Comp” for Calculation/Binary, Octal, Decimal, Hexadecimal Setting Mode.

Example	Operation	Display
999k (kilo) + 25k (kilo) = 1.024M (mega)	SHIFT SETUP ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ 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)

The logical operator menu lets you select the operator you need.

OPTN F6 (▷) F6 (▷) F4 (LOGIC)

F1 F2 F3

F1 (And) .... AND (logical multiplication)
F2 (Or) .... OR (logical addition)
F3 (Not) .... NOT (negation)

P.5

- Be sure to specify "Comp" for Calculation/Binary, Octal, Decimal, Hexadecimal Setting 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 ≠ 0	B ≠ 0	1	1
A ≠ 0	B = 0	0	1
A = 0	B ≠ 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 ≠ 0	0
A = 0	1

Chapter 3

Solve, Differential/Quadratic Differential, Integration, Maximum/Minimum Value, and Σ Calculations

3-1 Function Analysis Menu

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.

When the option menu is on the display, press F4 (CALC) to display the function analysis menu.

AC OPTN F4 (CALC)

F1 (Solve) ..... Used in Solve calculations

F2 (d/dx) .... Used in differential calculations

F3 (d^2/dx^2) ..... Used in quadratic differential calculations

F4 ($\int dx$) .... Used in integration calculations

F6 (▷) .... Previous menu

F6 (▷)

F1 (FMin) ...... Used in minimum calculations

F2 (FMax) ..... Used in maximum calculations

F3 (Σ() .... Used in Σ calculations

F6 (▷) .... Previous menu

3-2 Solve Calculations

P.64

To solve calculations, first display the function analysis menu, and then input the values shown in the formula below to determine root x values in the function $f(x)$.

F1 (Solve) $f(x)$, n , a , b)

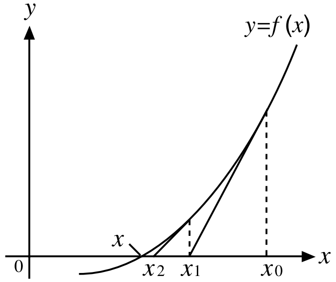
Initial estimate value (n)

Upper limit (b)

Lower limit (a)

With Solve calculations, the root of a function is determined 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_o 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.

•To perform solve calculations

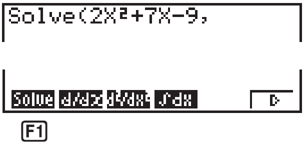
Example **To calculate the value of root x in the following formula when the initial estimated value is n = 1, the lower limit is a = 0, and the upper limit is b = 1:**

$2x^2 + 7x - 9 = 0$

Input the function $f(x)$.

AC OPTN F4 (CALC) F1 (Solve)

2 X,θ,T x^2 + 7 X,θ,T − 9 ,



Solve(2X²+7X-9,

Input initial estimated value *n*.

[1] [,]

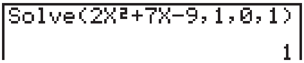
```
Solve(2X²+7X-9,1,
```

Input lower limit *a* and upper limit *b*.

[0] [,] [1] [)]

```
Solve(2X²+7X-9,1,0,1)
```

[EXE]



```
Solve(2X²+7X-9,1,0,1)
                    1
```

- 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.
- Roots obtained using Solve may include errors.

- Since Solve uses Newton's method, the following can sometimes occur.
  —Certain initial estimated values can make it impossible to obtain roots. In this case, try inputting another value that you assume to be near the root and perform the calculation again.
  —The calculator may be unable to obtain a root, even though a root exists.
- Due to certain idiosyncrasies of Newton's method, roots for the following types of functions tend to be difficult to calculate.
  —Periodic functions (i.e. sin $x = 0$)
  —Functions whose graph produce sharp slopes (i.e. $e^x = 0$, ${}^1/x = 0$)
  —Discontinuous functions (i.e. $\sqrt{x} = 0$)

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

3-3 Differential Calculations

P.64

- 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

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

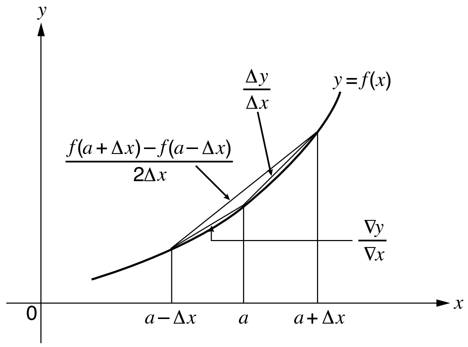
The differentiation for this type of calculation is defined as:

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

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 $\Delta x = 1$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 ,

```
d/dx(X^3+4X²+X-6,_
```

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

3 ,

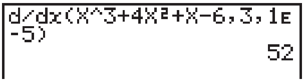
```
d/dx(X^3+4X²+X-6,3,_
```

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

1 EXP (−) 5)

```
d/dx(X^3+4X²+X-6,3,1E
-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.

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

Therefore:

$f'(a) + g'(a),\ f'(a) \times g'(a)$

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

Example $2 \times f'(a), \log(f'(a))$

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

Example $\frac{d}{dx}(\sin x + \cos x, \sin 0.5)$

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

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

3-4 Quadratic Differential Calculations

P.64

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.

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

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

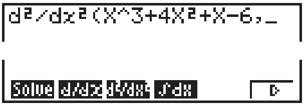
Example **To determine the quadratic differential coefficient at the point where $x = 3$ for the function $y = x^3 + 4x^2 + x - 6$**
Here we will use a final boundary value of n = 6.

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 ,

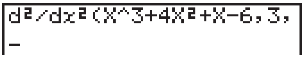


d²/dx²(X^3+4X²+X−6,_

F3

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

3 ,



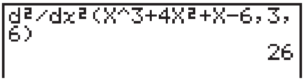
```
d²/dx²(X^3+4X²+X-6,3,
_
```

Input 6 as n, which is final boundary.

6)

```
d²/dx²(X^3+4X²+X-6,3,
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:

$$f''(a) + g''(a), \quad f''(a) \times g''(a)$$

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

$$2 \times f''(a), \quad \log(f''(a))$$

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

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

- 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 Ma ERROR.
- You can interrupt an ongoing quadratic differential calculation by pressing the AC key.
- You should always specify radians (Rad) as the unit of angle unit before performing a quadratic differential calculation using trigonometric functions.

3-5 Integration Calculations

P.64

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

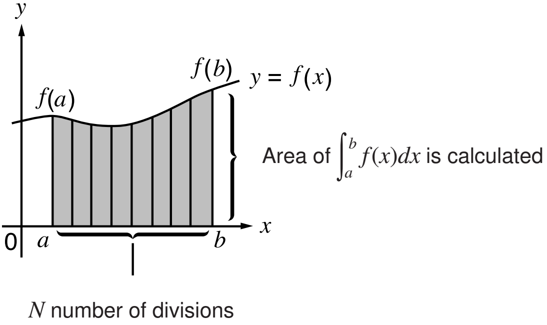
F4 (∫dx) $f(x)$, a , b , n)

Number of Divisions (value for n in N = 2^n, n is an integer from 1 through 9)

End Point

Start Point

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



Integration calculations are performed by applying Simpson's Rule for the $f(x)$ function you input. This method requires that the number divisions be defined as $N = 2^n$, where the value of n is an integer in the range of 1 through 9. If you do not specify a value for n, the calculator automatically assigns a value in accordance with the integration being performed.

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.

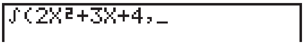
* If $f(x) < 0$ where $a \leqq x \leqq b$, the surface area calculation produces negative values (surface area × – 1).

●To perform an integration calculation

Example **To perform the integration calculation for the function**
$$\int_1^5 (2x^2 + 3x + 4)\, dx$$

Input the function *f* (*x*).

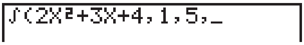
AC OPTN F4 (CALC) F4 ($\int dx$) 2 X,θ,T x^2
+ 3 X,θ,T + 4 ,



```
∫(2X²+3X+4,_
```

Input the start point and end point.

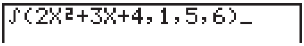
1 , 5 ,



```
∫(2X²+3X+4,1,5,_
```

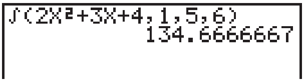
Input the number of divisions.

6)



```
∫(2X²+3X+4,1,5,6)_
```

EXE



```
∫(2X²+3X+4,1,5,6)
            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 n and the closing parenthesis can be omitted. If you omit n, the calculator automatically selects the most appropriate value.
- Calculation precision is theoretically ±1 at the least significant digit of the displayed result.

■ Application of Integration Calculation

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

Example $\int_a^b f(x)\, dx + \int_c^d g(x)\, dx$

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

Example $2 \times \int_a^b f(x)\, dx,\ \log\left(\int_a^b f(x)\, dx\right)$

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

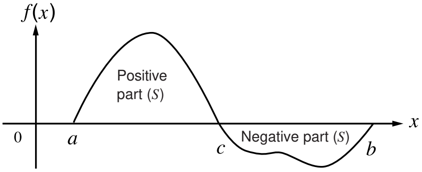
Example $\int_{\sin 0.5}^{\cos 0.5} (\sin x + \cos x)\, dx = \int (\sin x + \cos x, \sin 0.5, \cos 0.5, 5)$

- 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 $\boxed{\text{AC}}$ during calculation of an integral (while the cursor is not shown on the display) interrupts the calculation.
- Always perform trigonometric integrations using radians (Rad Mode) as the angle unit.
- This unit utilizes Simpson's rule for integration calculation. As the number of significant digits is increased, more calculation time is required. In some cases, calculation results may be erroneous even after considerable time is spent performing a calculation. In particular, when significant digits are less than 1, an ERROR (Ma ERROR) sometimes occurs.
- Integration involving certain types of functions or ranges can result in relatively large errors being generated in the values produced.

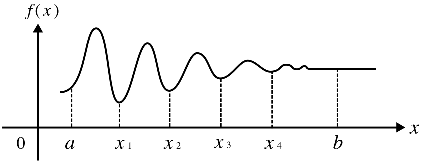
Note the following points to ensure correct integration values.

(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.



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

(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.



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

3-6 Maximum/Minimum Value Calculations

P.64

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 ~ 9)

End point of interval

Start point of interval

•Maximum Value

F6(▷) F2(FMax) $f(x)$, a , b , n)

Precision (n = 1 ~ 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 ,

```
FMin(X²-4X+9,_
```

F1

Input the interval a = 0, b = 3.

0 , 3 ,

```
FMin(X²-4X+9,0,3,_
```

Input the precision n = 6.

6)

```
FMin(X²-4X+9,0,3,6)_
```

EXE

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

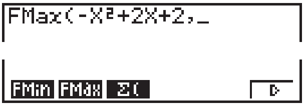
Example 2 **To determine the maximum value for the interval defined by start point $a = 0$ and end point $b = 3$, with a precision of $n = 6$ for the function $y = -x^2 + 2x + 2$**

Input $f(x)$.

AC OPTN F4(CALC)

F6(▷) F2(FMax)

(−) X,θ,T x^2 + 2 X,θ,T + 2 ,



```
FMax(-X²+2X+2,_
```

F2

Input the interval $a = 0$, $b = 3$.

0 , 3 ,

```
FMax(-X²+2X+2,0,3,_
```

Input the precision $n = 6$.

6)

```
FMax(-X²+2X+2,0,3,6)_
```

EXE

```
Ans
 1[    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 Ma 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 (Arg ERROR).

3-7 Σ Calculations

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

Last term of sequence {a_k}

Initial term of sequence {a_k}

Variable used by sequence {a_k}

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

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

$$S = a\alpha + a\alpha_{+1} + ...+ a\beta = \sum_{k=\alpha}^{\beta} a_k$$

■ 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 ,

```
Σ(K²-3K+5,_
```

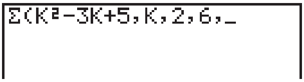
Input variable used by sequence {a_k}

ALPHA K ,

```
Σ(K²-3K+5,K,_
```

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

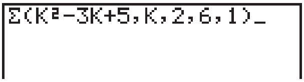
2 , 6 ,



```
Σ(K²-3K+5,K,2,6,_
```

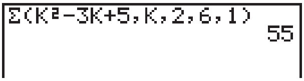
Input n.

1)



```
Σ(K²-3K+5,K,2,6,1)_
```

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.

■ Σ Calculation Precautions

- Make sure that the value used as the final term β is greater than the value used as the initial term α. Otherwise, an Ma 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.

OPTN F3 (CPLX)

F1 (*i*) .... Input of imaginary unit *i*

F2 (Abs) .... Calculation of absolute value

F3 (Arg) .... Calculation of argument

F4 (Conj) .... Calculation of conjugate

F5 (ReP) .... Extraction of real number part

F6 (ImP) .... Extraction of imaginary number part

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

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

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

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

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

F1

Example 2 (2 + i) × (2 – i)

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

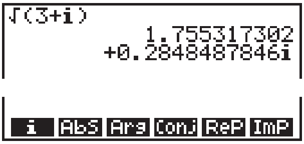
```
(2+i)×(2-i)
                   5
```

F1

Reciprocals, Square Roots, and Squares

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

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



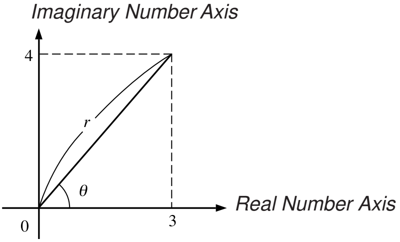
```
√(3+i)
        1.755317302
      +0.2848487846i
```

F1

Absolute Value and Argument

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).

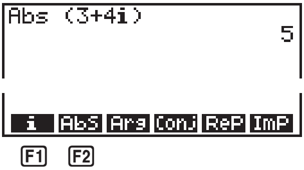
Example **To calculate absolute value (*r*) and argument (θ) for the complex number 3 + 4*i*, with the angle unit set for degrees**



AC OPTN F3(CPLX)F2(Abs)

(3 + 4 F1(*i*)) EXE

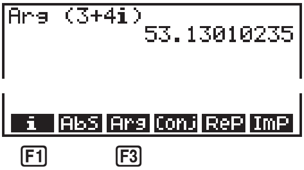
(Calculation of absolute value)


```
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).

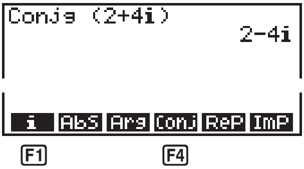
Conjugate Complex Numbers

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

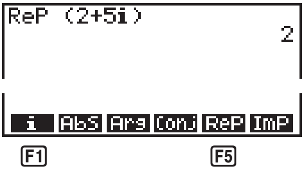

```
Conjg (2+4i)
                 2-4i
```

Extraction of Real and Imaginary Number Parts

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

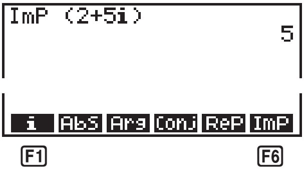
Example **To extract the real and imaginary parts of the complex number 2 + 5*i***

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
```

4-3 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.

P.25

- 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, $\overleftarrow{\text{ENG}}$, $\circ\,'\,''$, $\overleftarrow{\circ\,'\,''}$, $a\,{}^b\!/\!_c$, 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

P.5

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, so 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 in 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

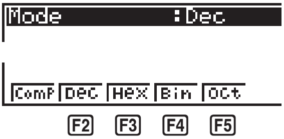
Positive: $0 \leqq x \leqq$ 7FFFFFFF

Negative: $80000000 \leqq x \leqq$ FFFFFFFF

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

1. In the main menu, select **RUN** icon.
2. Press SHIFT SET UP and then specify the defalut number system by pressing F2 (Dec), F3 (Hex), F4 (Bin), or F5 (Oct).

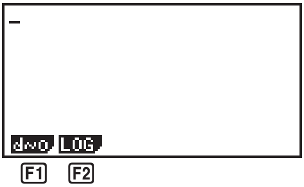
F2 (Dec)



Mode :Dec

3. Press EXIT to change to the screen for calculation input.

EXIT



F1 (d~o) .... Number system specification menu

F2 (LOG) .... 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

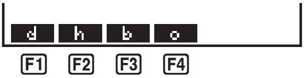
SHIFT SET UP F5(Oct) EXIT EXE


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.

F1(d ~ o)



F1 (d) .... Specifies decimal for input value
F2 (h) .... Specifies hexadecimal for input value
F3 (b) .... Specifies binary for input value
F4 (o) .... Specifies octal for input value

•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

Example 1 To calculate $10111_2 + 11010_2$

SHIFT SET UP F4 (Bin) EXIT

AC 1 0 1 1 1 +

1 1 0 1 0 EXE

```
10111+11010
      0000000000110001
```

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

SHIFT SET UP F2 (Dec) EXIT

AC F1 (d~o) F4 (o) 1 2 3 ×

F2 (h) A B C EXE

```
o123×hABC
                228084
```

SHIFT SET UP 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.

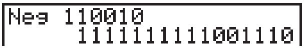
F2(LOG)

F1 (Neg) .... negation
F2 (Not) .... NOT
F3 (and) .... AND
F4 (or) .... OR
F5 (xor) .... XOR
F6 (xnor) .... XNOR

Negative Values

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

SHIFT SETUP 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 SETUP F3(Hex) EXIT
AC 1 2 0 F2(LOG)
F3(and) A D EXE

```
120andAD
            00000020
```

Example 2 **To calculate "36_8 or 1110_2" to its octal value**

SHIFT SETUP F5(Oct) 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 SETUP F3(Hex) EXIT
AC F2(LOG) F2(Not)
2 F F F E D EXE

```
Not 2FFFED
            FFD00012
```

Chapter 6

Matrix Calculations

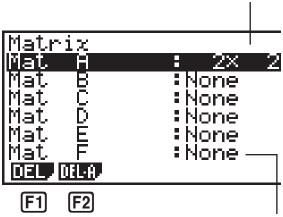
26 matrix memories (Mat A through Mat Z) plus a Matrix Answer Memory (MatAns), make it possible to perform the following matrix operations.

- 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 and press EXE 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
```

Not dimension preset

F1 (DEL) .... Delete specific matrix

F2 (DEL•A) .... Delete all matrices

- The maximum matrix dimension (size) is 255 (rows) × 255 (columns).

■ About Matrix Answer Memory (MatAns)

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

P.106

- 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.

■ 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.

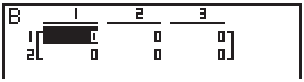
2 EXE

```
Matrix
Mat  A      :  2×  2
Mat  B      :  2×3_
```

Specify the number of columns.

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 :**

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

Select Mat B.

⏷

Matrix
Mat A : 2× 2
Mat B : 2× 3

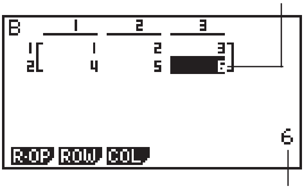
EXE

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)



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 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).

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).

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

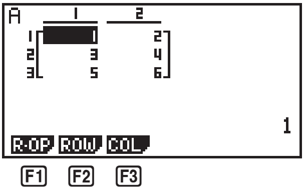
You can perform any of the following operations involving the cells of a matrix on the display.

- Row swapping, scalar product, addition
- Row deletion, insertion, addition
- Column deletion, insertion, addition

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.

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



F1 (R•OP) ..... Row calculation menu
F2 (ROW)...... Row operation menu
F3 (COL) .... 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.

F1(R•OP)

F1 (Swap) ..... Row swap
F2 (xRw) .... Scalar product for a specific row
F3 (xRw+) ..... Addition of scalar product of specific row to another row
F4 (Rw+) .... Addition of contents of specific row to another row

•To swap two rows

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

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

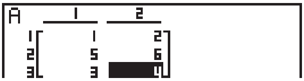
F1(R•OP) F1(Swap)

```
m? _
  Swap Row m↔Row n
```

Input the number of the rows you want to swap.

2 EXE

3 EXE



```
A     1    2
1[    1    2]
2     5    6
3L    3    4]
```

•To calculate the scalar product of a row

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

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

F1(R•OP)

F2(×Rw)

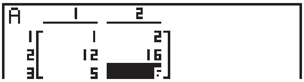
```
k? _
   k×Row m→Row m
```

Input multiplier value.

4 EXE

Specify row number.

2 EXE



```
A     1    2
1[    1    2]
2    12   16
3L    5    6]
```

•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 by 4 and add the result to row 3 :**

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

F1(R•OP)

F3(×Rw+)

```
k? _
 k×Row m+Row n→Row n
```

Input multiplier value.

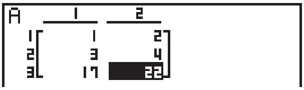
4 EXE

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
3L   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)

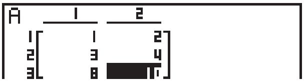
F4(Rw+)

Specify number of row to be added.

2 EXE

Specify number of row to be added to.

3 EXE



Row Operations

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

F2 (ROW)

F1 (DEL) .... Delete row

F2 (INS) .... Insert row

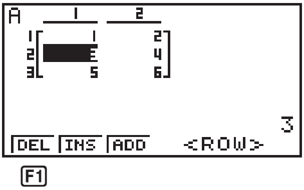
F3 (ADD) .... Add row

•To delete a row

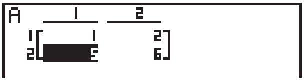
Example **To delete row 2 of the following matrix :**

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

F2(ROW) ⏷



F1(DEL)

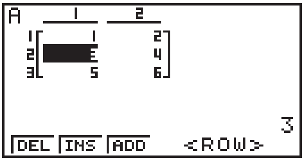


•To insert a row

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

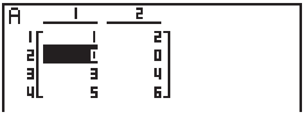
$$\text{Matrix A} = \begin{bmatrix}1 & 2\\ 3 & 4\\ 5 & 6\end{bmatrix}$$

F2(ROW) ▼



F2

F2(INS)

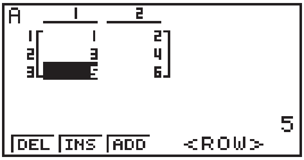


•To add a row

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

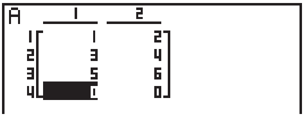
$$\text{Matrix A} = \begin{bmatrix}1 & 2\\ 3 & 4\\ 5 & 6\end{bmatrix}$$

F2(ROW) ▼ ▼



F3

F3(ADD)



■ Column Operations

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

F3 (COL)

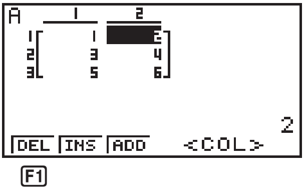
- F1 (DEL) .... Delete column
- F2 (INS) .... Insert column
- F3 (ADD) .... Add column

•To delete a column

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

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

F3(COL)▶



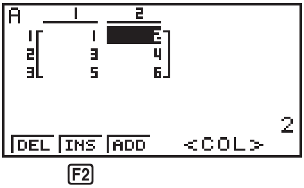
F1(DEL)

•To insert a column

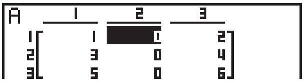
Example **To insert a new column between columns 1 and 2 of the following matrix :**

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

F3(COL)▶



F2 (INS)


A

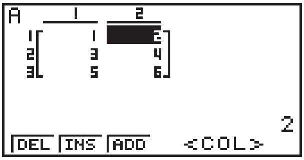
$$\begin{array}{c|ccc} & 1 & 2 & 3 \\ \hline 1 & 1 & 0 & 2 \\ 2 & 3 & 0 & 4 \\ 3 & 5 & 0 & 6 \end{array}$$

•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) ▶

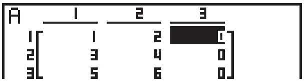

A

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

2

F3

F3 (ADD)


A

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

6-3 Modifying Matrices Using Matrix Commands

In addition to using the MATRIX list to create and modify a matrix, you can also use matrix commands to input data and create a matrix without actually displaying it.

•To display the matrix commands

P.31

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.

OPTN F2 (MAT)

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

P.105

F1 (Mat) .... Mat command (matrix specification)

F2 (M→L) ...... Mat→List command (assign contents of selected column to list file)

F5 (Aug) .... Augment command (link two matrices)

F6 (▷) .... Next menu

F6 (▷)

F1 (Iden) .... Identity command (identity matrix input)

F2 (Dim) .... Dim command (dimension check)

F3 (Fill) .... Fill command (identical cell values)

F6 (▷) .... Previous menu

■ 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.

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

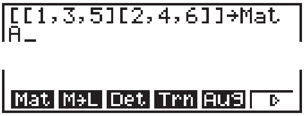
$= [\,[a_{11}, a_{12}, ..., a_{1n}]\ [a_{21}, a_{22}, ..., a_{2n}]\ ....\ [a_{m1}, a_{m2}, ..., a_{mn}]\,]$
→ Mat [letter A through Z]

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

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

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

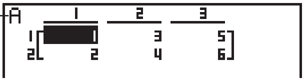
OPTN F2 (MAT)
SHIFT [SHIFT [1 , 3 , 5
SHIFT] SHIFT [2 , 4 , 6
SHIFT] SHIFT] → F1 (Mat) ALPHA A



```
[[1,3,5][2,4,6]]→Mat
A_
```

F1

EXE



```
A     1     2     3
1 [   1     3     5 ]
2 [   2     4     6 ]
```

- An error (Mem 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.

P.101

•To input an identity matrix

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

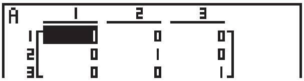
Example 2 **To create a 3 × 3 identity matrix as Matrix A**

OPTN F2 (MAT)
F6 (▷) F1 (Iden) 3 →
Number of rows/columns
F6 (▷) F1 (Mat) ALPHA A

```
Identity 3→Mat A
```

F1

EXE



```
A     1     2     3
1 [   1     0     0 ]
2     0     1     0
3 [   0     0     1 ]
```

P.101

•To check the dimensions of a matrix

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

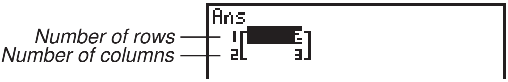
Example 3 **To check the dimensions of Matrix A, which was input in Example 1**

OPTN F2 (MAT)
F6 (▷) F2 (Dim) F6 (▷) F1 (Mat)
ALPHA A

```
Dim Mat A_
```

F1

EXE



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

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

P.101

■ 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
```

F1

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
```

F1

P.101

•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][,]

Filler value

[F6](▷)[F1](Mat)[ALPHA][A]


```
Fill(3,Mat A_
```

[EXE]


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

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

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

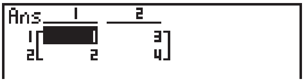
[OPTN] [F2](MAT)

[F5](Aug)[F1](Mat)[ALPHA][A][,]

[F1](Mat)[ALPHA][B]


```
Augment(Mat A,Mat B_
```

[EXE]


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

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

P.101

•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
```

F1

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 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

Use the matrix command menu to perform matrix calculation operations.

P.31

•To display the matrix commands

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.

OPTN F2(MAT)

The following describes only the matrix commands that are used for matrix arithmetic operations.

F1 (Mat) .... Mat command (matrix specification)
F3 (Det) .... Det command (determinant command)
F4 (Trn) .... Trn command (transpose matrix command)
F6 (▷) .... Next menu

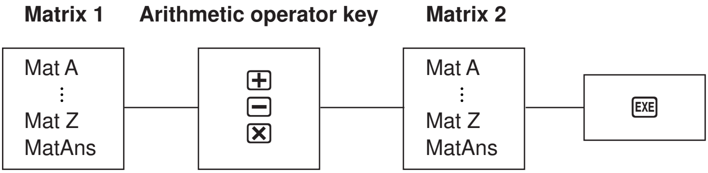
F6 (▷)

F1 (Iden) .... Identity command (identity matrix input)
F6 (▷) .... Previous menu

All of the following examples assume that matrix data is already stored in memory.

■ Matrix Arithmetic Operations

The following is the format for matrix arithmetic operations.



Example 1 **To add the following two matrices (Matrix A + Matrix B) :**

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

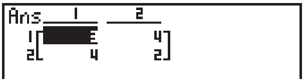
F1 (Mat) ALPHA A +

F1 (Mat) ALPHA B

```
Mat A+Mat B_
```

F1

EXE



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

This display indicates the following result.

$$A + B = \begin{bmatrix} 3 & 4 \\ 4 & 2 \end{bmatrix}$$

Example 2 **To multiply the two matrices in Example 1 (Matrix A × Matrix B)**

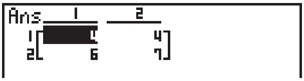
F1 (Mat) ALPHA A ×

F1 (Mat) ALPHA B

```
Mat A×Mat B_
```

F1

EXE



```
Ans   1     2
  1[  4     4]
  2[  6     7]
```

This display indicates the following result.

$$A \times B = \begin{bmatrix} 4 & 4 \\ 6 & 7 \end{bmatrix}$$

- The two matrices must have the same dimensions in order to be added or subtracted. An error (Dim 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 (Dim 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 (F1) command to input the identity matrix.

Example 3 **To multiply Matrix A (from Example 1) by a 2 × 2 identity matrix**

F1(Mat) ALPHA A ×

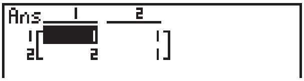
F6(▷) F1(Iden) 2

Number of rows and columns.

Mat A×Identity 2_

F1

EXE

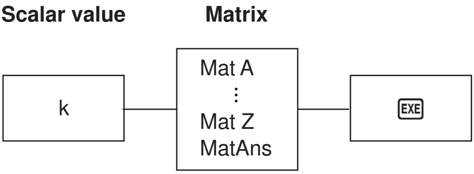


This display indicates the following result.

$$A \times E = \begin{bmatrix} 1 & 1 \\ 2 & 1 \end{bmatrix}$$

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 :**

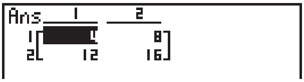
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

4 F1(Mat) ALPHA A

4Mat A_

F1

EXE

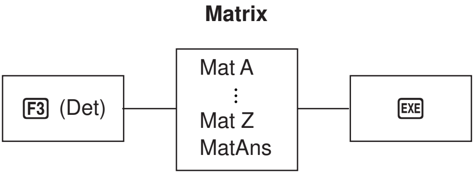


This display indicates the following result.

$$4A = \begin{bmatrix} 4 & 8 \\ 12 & 16 \end{bmatrix}$$

Determinant

The following is the format for obtaining a 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
```

F1

This display indicates determinant |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 (Dim ERROR).

- The determinant of a 2 × 2 matrix is calculated as shown below.

$$|A| = \begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix} = a_{11}a_{22} - a_{12}a_{21}$$

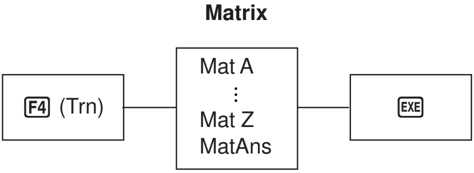
- The determinant of a 3 × 3 matrix is calculated as shown below.

$$|A| = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

$$= a_{11}a_{22}a_{33} + a_{12}a_{23}a_{31} + a_{13}a_{21}a_{32} - a_{11}a_{23}a_{32} - a_{12}a_{21}a_{33} - a_{13}a_{22}a_{31}$$

Matrix Transposition

A matrix is transposed when its rows become columns and its columns become rows. The following is the format for matrix transposition.



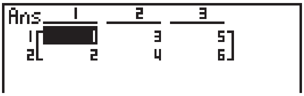
Example **To transpose the following matrix:**

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

F4 (Trn) F1 (Mat) ALPHA A


```
Trn Mat A_
```

EXE

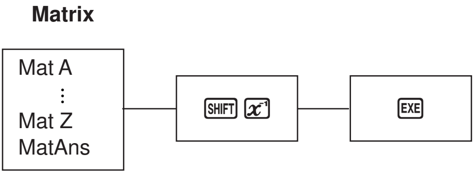

```
Ans     1     2     3
  1 [   1     3     5 ]
  2 [   2     4     6 ]
```

This operation produces the following result.

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

Matrix Inversion

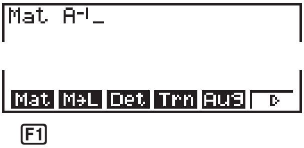
The following is the format for matrix inversion.



Example **To invert the following matrix :**

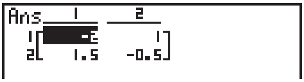
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

F1 (Mat) ALPHA A SHIFT x^{-1}



Mat A⁻¹_

EXE



$$\begin{array}{c|cc} \text{Ans} & 1 & 2 \\ \hline 1 & -2 & 1 \\ 2 & 1.5 & -0.5 \end{array}$$

This operation produces the following result.

$$A^{-1} = \begin{bmatrix} -2 & 1 \\ 1.5 & -0.5 \end{bmatrix}$$

- Only square matrices (same number of rows and columns) can be inverted. Trying to invert a matrix that is not square produces an error (Dim ERROR).
- A matrix with a value of zero cannot be inverted. Trying to invert a matrix with value of zero produces an error (Ma 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}.

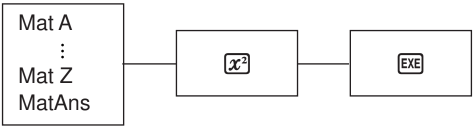
$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

$$A^{-1} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$ Note that $ad - bc \neq 0$.

Squaring a Matrix

The following is the format for squaring a matrix.

Matrix



Example **To square the following matrix :**

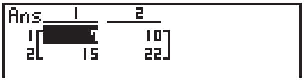
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

[F1] (Mat) [ALPHA] [A] [x^2]

```
Mat A²_

Mat M→L Det Trn Aug ▷
```

[F1]

[EXE]



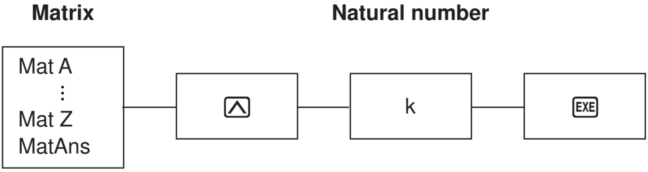
```
Ans    1      2
  1[   7     10]
  2[  15     22]
```

This operation produces the following result.

$$A^2 = \begin{bmatrix} 7 & 10 \\ 15 & 22 \end{bmatrix}$$

Raising a Matrix to a Power

The following is the format for raising a matrix to a power.



Example **To raise the following matrix to the third power :**

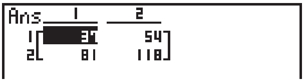
$$\text{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

[F1] (Mat) [ALPHA] [A] [^] [3]

```
Mat A^3_

Mat M→L Det Trn Aug ▷
```

[F1]

[EXE]



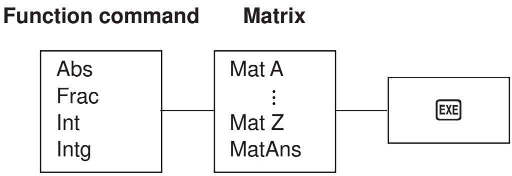
```
Ans    1      2
  1[  37     54]
  2[  81    118]
```

This operation produces the following result.

$$A^3 = \begin{bmatrix} 37 & 54 \\ 81 & 118 \end{bmatrix}$$

Determining the Absolute Value, Integer Part, Fraction Part, and Maximum Integer of a Matrix

The following is the format for using a matrix in built in functions to obtain an absolute value, integer part, fraction part, and maximum integer.



Example **To determine the absolute value of the following matrix :**

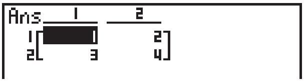
$$\textbf{Matrix A} = \begin{bmatrix} 1 & -2 \\ -3 & 4 \end{bmatrix}$$

OPTN F6 (▷) F4 (NUM) F1 (Abs)
OPTN F2 (MAT) F1 (Mat) ALPHA A


Abs Mat A_

F1

EXE



This operation produces the following result.

$$\textbf{Abs A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix}$$

- 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 required 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 (Mem ERROR) occurs.
- You can use the following operations 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 a 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:

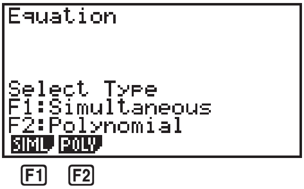
- Linear equations with two to six unknowns
- Quadratic equations
- Cubic equations

7-1 Before Beginning an Equation Calculations

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

Highlight the **EQUA** icon on the Main Menu and then press EXE.



Equation

Select Type
F1:Simultaneous
F2:Polynomial

F1(SIML) .... Linear equation with two to six unknowns

F2(POLY) ...... Quadratic or cubic equation

Clearing Equation Memories

After entering an equation calculation mode (SIML or POLY), clear the calculation memory for that mode. In the case of SIML, use the function keys to specify the number of unknowns, from two (F1) to six (F5). In the case of POLY, use the function keys to specify either two (F1) or three (F2) polynomials.

F2(DEL)

Press F1 (YES) to clear the equation memories of that mode (SIML or POLY), or F6 (NO) to abort the clear operation without clearing 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

$$a_1x + b_1y = c_1$$
$$a_2x + b_2y = c_2$$

$$\vdots \qquad \vdots$$

Six unknowns

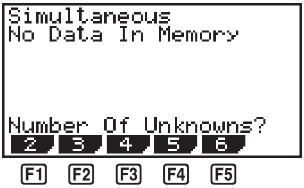
$$a_1x + b_1y + c_1z + d_1t + e_1u + f_1v = g_1$$
$$a_2x + b_2y + c_2z + d_2t + e_2u + f_2v = g_2$$
$$a_3x + b_3y + c_3z + d_3t + e_3u + f_3v = g_3$$
$$a_4x + b_4y + c_4z + d_4t + e_4u + f_4v = g_4$$
$$a_5x + b_5y + c_5z + d_5t + e_5u + f_5v = g_5$$
$$a_6x + b_6y + c_6z + d_6t + e_6u + f_6v = g_6$$

- You can also solve linear equations with three, four, and five unknowns. In each case, the format is similar to those shown above.

■ Entering the Linear Equation Mode for Two to Six Unknowns

While the Equation Mode is displayed, press F1 (SIML).

F1(SIML)



Simultaneous
No Data In Memory

Number Of Unknowns?

F1(2) .... Linear equation with two unknowns
F2(3) .... Linear equation with three unknowns
F3(4) .... Linear equation with four unknowns
F4(5) .... Linear equation with five unknowns
F5(6) .... Linear equation with six unknowns

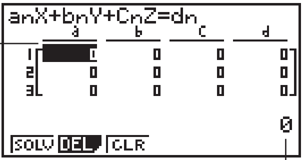
Solving Linear Equations with Three Unknowns

Example **To solve the following linear equations for x, y, and z:**

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

While in the Linear Equation Mode (SIML), press F2 (3), because the linear equations being solved have three unknowns.

F2(3)

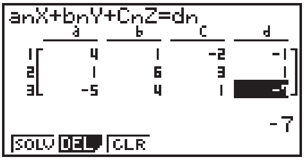


Coefficient input cells

Value being input into highlighted cell

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



F1

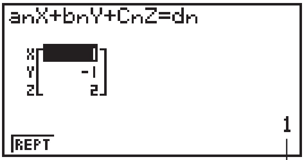
Each time you press EXE, the input value is registered in the highlighted cell. Each press of EXE inputs values in the following sequence:

coefficient a_1 → coefficient b_1 → coefficient c_1 → coefficient d_1 →
coefficient a_2 → coefficient b_2 → coefficient c_2 → coefficient d_2 →
coefficient a_3 → coefficient b_3 → coefficient c_3 → coefficient d_3

- You can input fractions and value memory contents as coefficients.

After inputting the coefficients, solve the equations.

F1(SOLV)



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 “Ma 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.

F3(CLR)

7-3 Quadratic and Cubic Equations

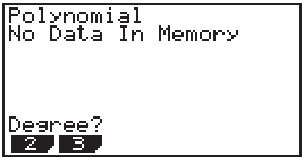
This calculator can also solve quadratic and cubic equations that match the following formats (when $a \neq 0$):

- **Quadratic:** $ax^2 + bx + c = 0$
- **Cubic:** $ax^3 + bx^2 + cx + d = 0$

Entering the Quadratic/Cubic Equation Mode

While in the Equation Mode, press F2 (POLY).

F2(POLY)



Polynomial
No Data In Memory

Degree?

F1 F2

F1(2) .... Quadratic equation

F2(3) .... Cubic equation

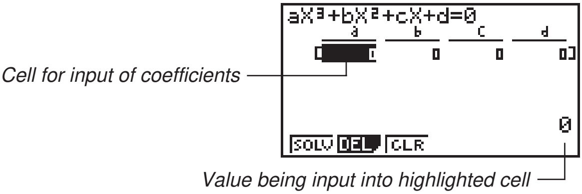
Solving a Quadratic or Cubic Equation

Example **To solve the following cubic equation:**

$$x^3 - 2x^2 - x + 2 = 0$$

Press F2 (3) to enter the Cubic Equation Mode.

F2(3)



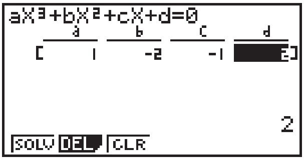
$aX^3+bX^2+cX+d=0$

Cell for input of coefficients

Value being input into highlighted cell

Input each coefficient.

1 EXE (−) 2 EXE
(−) 1 EXE 2 EXE



$aX^3+bX^2+cX+d=0$

F1

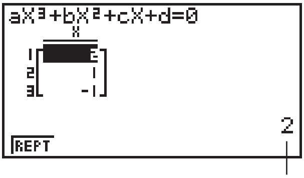
- Each time you press EXE, the input value is registered in the highlighted cell. Each press of EXE inputs values in the following sequence:

  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.

After inputting the coefficients, press F1 (SOLV) to solve the equations.

F1(SOLV)



```
aX³+bX²+cX+d=0
      X
 1[     3]
 2[     1]
 3[    -1]
                2
REPT
```

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 “Ma ERROR” occurs whenever the unit is unable to solve the equations.
- Pressing F1 (REPT) returns to the initial display of the Cubic Equation Mode.

■ Quadratic equations that produce multiple root (1 or 2) solutions or imaginary number solutions

The following examples illustrate how multiple-root solutions and imaginary number solutions are handled.

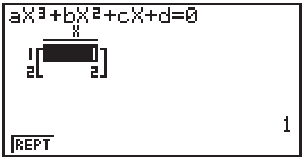
●To solve a cubic equation that produces a multiple-value solution

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[     1]
 2[     2]
                1
REPT
```

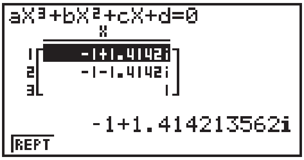
•To solve a cubic equation that produces an imaginary number solution

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
REPT
```

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.

F3(CLR)

7-4 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.

- Note that even when you press the AC key, the values assigned for coefficients are retained.

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.

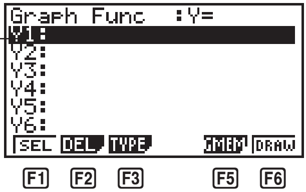
- Rectangular coordinate (Y =) graphs
- Polar coordinate (r =) graphs
- Parametric graphs
- X = constant graphs
- Inequality graphs
- Integration graphs (in the RUN mode only)

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.



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

Memory area

Use ▲ and ▼ to change selection.

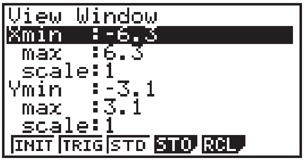
F1 (SEL) .... Draw/non-draw status
F2 (DEL) .... Graph delete
F3 (TYPE) ..... Graph Type Menu
F5 (GMEM) ... Graph memory save/recall
F6 (DRAW).... Draws graph

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. Press SHIFT F3 to display the View Window.

1. Press SHIFT F3 to display the View Window.

SHIFT F3 (V-Window)



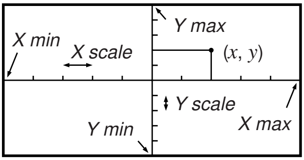
```
View Window
Xmin  :-6.3
 max  :6.3
 scale:1
Ymin  :-3.1
 max  :3.1
 scale:1
INIT TRIG STD STO RCL
```

F1 F2 F3 F4 F5

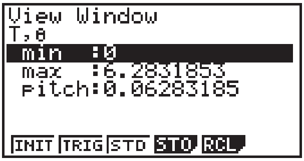
P.129	F1 (INIT)	View Window initial settings
P.129	F2 (TRIG)	View Window initial settings using specified angle unit
P.130	F3 (STD)	Standardized View Window settings
P.130	F4 (STO)	Store View Window settings to View Window memory.
P.130	F5 (RCL)	Recall View Window settings from View Window memory.

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

The following 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 ▼.



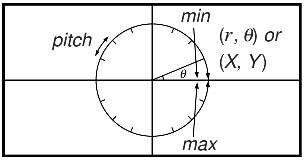
```
View Window
T,θ
 min  :0
 max  :6.2831853
 pitch:0.06283185

INIT TRIG STD STO RCL
```

T, θ min .... T, θ minimum values

T, θ max .... T, θ maximum values

T, θ pitch .... T, θ pitch

The following 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, the axis is 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 setting 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 (Ma ERROR).

■ Initializing and Standardizing the View Window

●To initialize the View Window

a. 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

b. 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

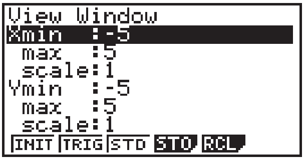
■ View Window Memory

You can store up to six sets of View Window settings in View Window memory for recall when you need them.

•To save View Window settings

Example **To save the following View Window settings :**

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



```
View Window
Xmin   :-5
 max   :5
 scale:1
Ymin   :-5
 max   :5
 scale:1
```

F4

F4 (STO)

F1 (V·W1)

- Storing View Window settings in a memory area (V·W1 through V·W6) that already contains settings replaces the existing settings with the new ones.

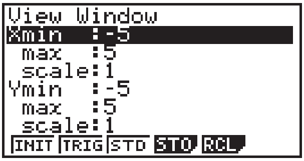
•To recall View Window settings

Example **To recall the View Window settings in V·W1**

F5

F5 (RCL)

F1(V·W1)


View Window
Xmin :-5
max :5
scale:1
Ymin :-5
max :5
scale:1

- 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. The types of functions that can be stored in memory are: rectangular coordinate functions, polar coordinate functions, parametric functions, inequalities, and X = constant expressions.

Specifying the Graph Type

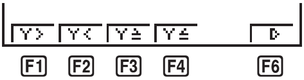
Before you can store a graph function in memory, you must first specify its graph type.

1. While the Graph Function Menu is on the display, press F3 (TYPE) to display a Graph Type Menu.

F3 (TYPE)

F1 (Y =) .... Rectangular coordinate graph
F2 (r =) .... Polar coordinate graph
F3 (Parm) ...... Parametric graph
F4 (X = c) ...... X = constant graph
F6 (▷) .... Next menu

F6 (▷)



F1 (Y >) .... Y > $f(x)$ inequality
F2 (Y <) .... Y < $f(x)$ inequality
F3 (Y ≥) .... Y ≧ $f(x)$ inequality
F4 (Y ≤) .... Y ≦ $f(x)$ inequality
F6 (▷) .... Previous menu

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.)

```
Graph Func   :Y=
Y1=2X²-5_
```

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 θ

F3(TYPE) F2(r =)

(Specifies polar coordinate expression.)

```
Graph Func   :r=
r2=5sin 3θ
```

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.)

```
Graph Func   :Param
Xt3:
Yt3:
```

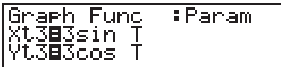
3 sin X,θ,T EXE

(Inputs and stores x expression.)

```
Graph Func   :Param
Xt3■3sin T
Yt3:
```

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.)

```
Graph Func   :X=const
X4=3_
```

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 (Syn 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.)

```
Graph Func   :Y>
Y5>X²-2X-6_
```

X,θ,T x² − 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.)

```
Graph Func   :Y=
Y1=2X²-3_
```

▶ ▶ ▶ ▶ 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

Before actually drawing a graph, you should first make the following specification.

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

You can specify which functions out of those stored in memory should be used for a draw operation.

- Graphs for which there is no draw/non-draw status specification are not drawn.

Example **To select the following functions for drawing :**

Y1 = $2x^2 - 5$

r2 = 5 sin3θ

Use the following View Window parameters.

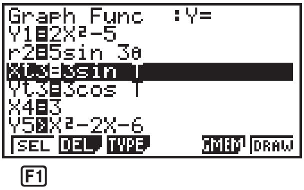
Xmin = –5 **Ymin** = –5

Xmax = 5 **Ymax** = 5

Xscale = 1 **Yscale** = 1

▼ ▼

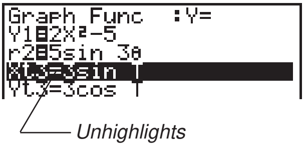
(Select a memory area that contains a function for which you want to specify non-draw.)



```
Graph Func   :Y=
Y1■2X²-5
r2■5sin 3θ
Xt3■3sin T
Yt3■3cos T
X4■3
Y5■X²-2X-6
```

F1 (SEL)

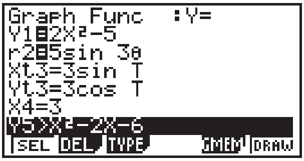
(Specify non-draw.)



```
Graph Func   :Y=
Y1■2X²-5
r2■5sin 3θ
Xt3=3sin T
Yt3=3cos T
```

▼ ▼ F1 (SEL)

▼ F1 (SEL)

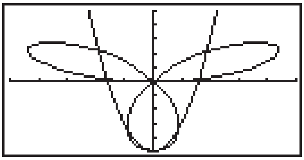


```
Graph Func   :Y=
Y1■2X²-5
r2■5sin 3θ
Xt3=3sin T
Yt3=3cos T
X4=3
Y5>X²-2X-6
SEL DEL TYPE     GMEM DRAW
```

F6

F6 (DRAW) or EXE

(Draws graphs.)



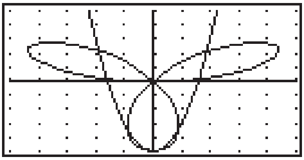
- Pressing SHIFT F6 (G↔T) or AC returns to the Graph Function Menu.

P.6

- You can use the set up screen settings to alter the appearance of the graph screen as shown below.

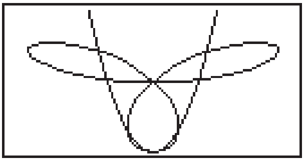
- Grid: On

  This setting causes dots to appear at the grid intersects on the display.



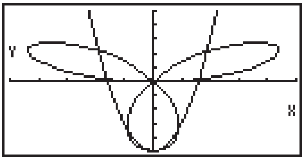
- Axes: Off

  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 (Syn ERROR).

8-4 Graph Memory

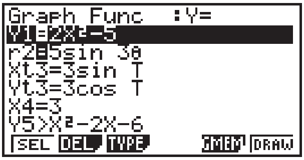
Graph memory lets you store up to six sets of graph function data and recall it later when you need it.

A single save operation saves the following data stored in graph memory.

- All graph functions in the currently displayed Graph Function Menu (up to 20)
- Graph types
- Draw/non-draw status
- View Window settings (1 set)

•To save graph functions in graph memory

Example **To store the graph functions shown on the screen below in graph memory GM1**



```
Graph Func  :Y=
Y1=2X²-5
r2=5sin 3θ
Xt3=3sin T
Yt3=3cos T
X4=3
Y5>X²-2X-6
```

F5

F5(GMEM)

F1

F1(STO)

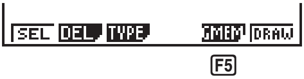
F1

F1(GM1)

- Storing data in a memory area (GM1 through GM6) that already contains data replaces the existing data with the new data.
- If the data exceeds the calculator's remaining memory capacity, an error (Mem ERROR) occurs.

•To recall graph functions from graph memory

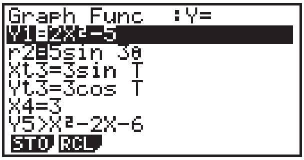
Example **To recall the data in graph memory GM1**



F5(GMEM)

F2(RCL)

F1(GM1)



```
Graph Func  :Y=
Y1=2X²-5
r2=5sin 3θ
Xt3=3sin T
Yt3=3cos T
X4=3
Y5>X²-2X-6
```

- 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.

SHIFT F4 (Sketch)
F5 (GRPH)

F1 (Y =) .... Rectangular coordinate graph
F2 (r =) .... Polar coordinate graph
F3 (Parm) ...... Parametric graph
F4 (X = c) ...... X = constant graph
F5 (G∫dx) .... For drawing integration graphs
F6 (▷) .... Next menu

F6 (▷)

F1 (Y >) .... Y > $f(x)$ inequality
F2 (Y <) .... Y < $f(x)$ inequality
F3 (Y ≥) .... Y ≧ $f(x)$ inequality
F4 (Y ≤) .... Y ≦ $f(x)$ inequality
F6 (▷) .... Previous menu

•To graph using rectangular coordinates (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.

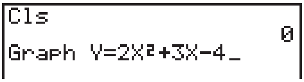
Xmin	**= –5**	**Ymin**	**= –10**
Xmax	**= 5**	**Ymax**	**= 10**
Xscale	**= 2**	**Yscale**	**= 5**

1. In the set-up screen, specify the appropriate graph type for Func Type.

SHIFT SET UP ▼ F1 (Y =) EXIT

2. Input the rectangular coordinate (Y =) expression.

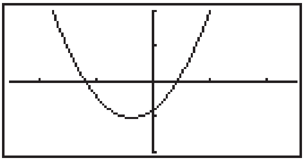
SHIFT F4 (Sketch) F1 (Cls) EXE
F5 (GRPH) F1 (Y =)
2 X,θ,T x^2 + 3 X,θ,T − 4



```
Cls
                0
Graph Y=2X²+3X-4_
```

3. Press EXE to draw the graph.

EXE



- 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 =)

You can graph functions that can be expressed in the format $r = f(\theta)$.

Example **To graph r = 2 sin3θ**

Use the following View Window parameters.

Xmin = –3 **Ymin** = –2
Xmax = 3 **Ymax** = 2
Xscale = 1 **Yscale** = 1
T, θ min = 0 **T, θ max** = π
T, θ pitch = π÷36

1. In the set-up screen, specify the appropriate graph type for Func Type.

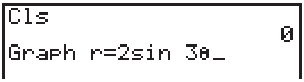
SHIFT SET UP ▼ F2 (r =)

2. Set the default unit of angular measurement to radians (Rad).

▼ ▼ ▼ F2 (Rad) EXIT

3. Input the polar coordinate expression (r =).

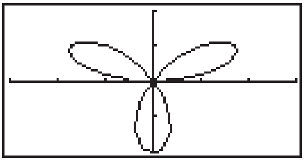
SHIFT F4 (Sketch) F1 (Cls) EXE
F5 (GRPH) F2 (r =)
2 sin 3 X,θ,T



```
Cls
                 0
Graph r=2sin 3θ_
```

4. Press EXE to draw the graph.

EXE



- 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

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**
Xmax = 20 **Ymax = 12**
Xscale = 5 **Yscale = 5**
T, θ min = 0 **T, θ max = 4π**
T, θ pitch = π÷36

1. In the set-up screen, specify the appropriate graph type for Func Type.

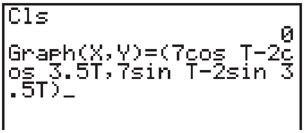
   SHIFT SETUP ▼ F3 (Parm)

2. Set the default angle unit to radians (Rad).

   ▼ ▼ ▼ F2 (Rad) EXIT

3. Input the parametric functions.

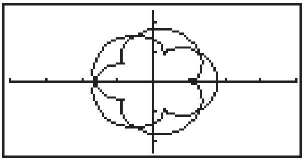
   SHIFT F4 (Sketch) F1 (Cls) EXE
   F5 (GRPH) F3 (Parm)
   7 cos X,θ,T − 2 cos 3 . 5 X,θ,T ,
   7 sin X,θ,T − 2 sin 3 . 5 X,θ,T)



```
Cls
                    0
Graph(X,Y)=(7cos T-2c
os 3.5T,7sin T-2sin 3
.5T)_
```

4. Press EXE to draw the graph.

   EXE



•To graph X = constant

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 the appropriate graph type for Func Type.

   SHIFT SETUP ▼ F4 (X = c) EXIT

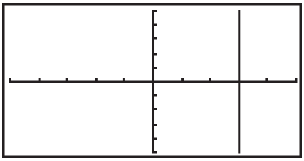
2. Input the expression.

   SHIFT F4 (Sketch) F1 (Cls) EXE
   F5 (GRPH) F4 (X = c) 3

```
Cls
                    0
Graph X=3_
```

3. Press EXE to draw the graph.

EXE



•To graph inequalities

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

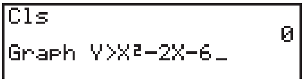
Xscale = 1 **Yscale** = 5

1. In the set-up screen, specify the appropriate graph type for Func Type.

SHIFT SET UP ▼ F6 (▷) F1 (Y>) EXIT

2. Input the inequality.

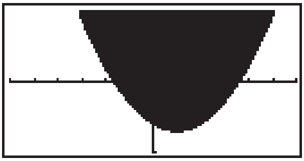
SHIFT F4 (Sketch) F1 (Cls) EXE
F5 (GRPH) F6 (▷)
F1 (Y>) X,θ,T x^2 − 2 X,θ,T − 6



```
Cls
                  0
Graph Y>X²-2X-6_
```

3. Press EXE to draw the graph.

EXE



•To draw an integration graph

You can graph an integration calculation performed using the function $y = f(x)$.

Example **To graph the following:**

$$\int_{-2}^{1} (x + 2)(x - 1)(x - 3)\,dx$$

Use the following View Window parameters.

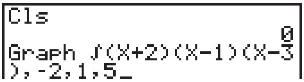
Xmin = –4 **Ymin = –8**
Xmax = 4 **Ymax = 12**
Xscale = 1 **Yscale = 5**

1. In the set-up screen, specify the appropriate graph type for Func Type.

SHIFT SET UP ▼ F1 (Y =) EXIT

2. Input the integration graph expression.

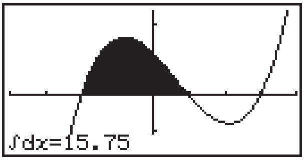
SHIFT F4 (Sketch) F1 (Cls) EXE
F5 (GRPH) F5 (G∫*dx*) (X,θ,T + 2)
(X,θ,T − 1) (X,θ,T − 3)
, (−) 2 , 1 , 5



```
Cls
                  0
Graph ∫(X+2)(X-1)(X-3
),-2,1,5_
```

3. Press EXE to draw the graph.

EXE



∫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.

P.6

■ 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 ▲, ▼, ◀, and ▶ 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=0.78539816339
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:**

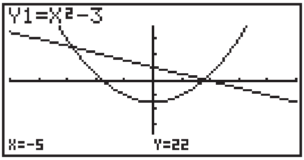
Y1 = x^2 – 3
Y2 = –x + 2

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.

F1(Trace)



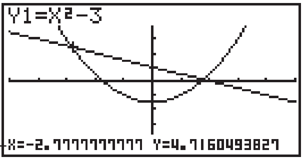
Y1=X²−3

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

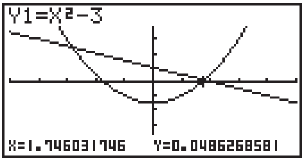
X=−2.7777777777 Y=4.7160493827

x/*y* *coordinate values*

- 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

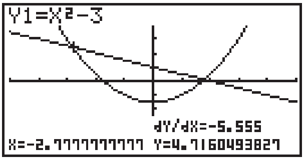
X=1.746031746 Y=0.0486268581

- To abort a trace operation, press F1 (Trace).
- Do not press the AC key while performing a trace operation.

P.6

•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

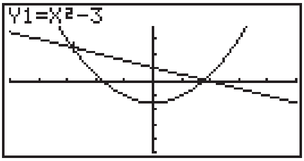
```
                 dY/dX=-12.6
X=-6.3           Y<38.69
```

P.141

- The derivative is not displayed when you use trace with a built-in scientific function.

P.6

- 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.

P.8

- 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**

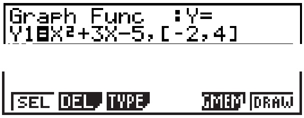
F3(TYPE) F1(Y =)

(Specifies graph type.)

X,θ,T x^2 + 3 X,θ,T − 5 ,

SHIFT [(−) 2 , 4 SHIFT] EXE

(Stores expression.)



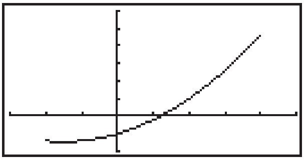
Graph Func :Y=

Y1■X²+3X-5,[-2,4]

F6

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.

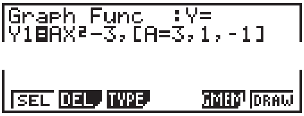
Xmin = –5 **Ymin = –10**
Xmax = 5 **Ymax = 10**
Xscale = 1 **Yscale = 2**

F3(TYPE) F1(Y =)

(Specifies graph type.)

ALPHA A X,θ,T x^2 − 3 ,
SHIFT [ALPHA A SHIFT = 3 ,
1 , (−) 1 SHIFT] EXE

(Stores expression.)

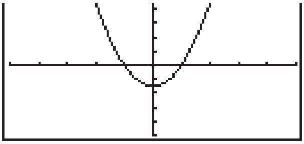


```
Graph Func  :Y=
Y1■AX²-3,[A=3,1,-1]
```

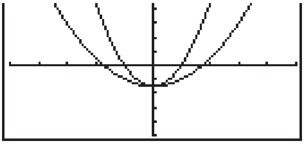
F6

F6(DRAW)

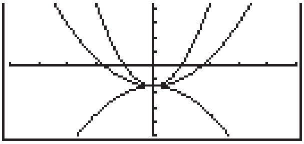
(Draws graph.)



↓



↓



- The function 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.
- 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.

P.8

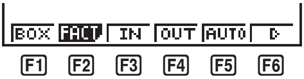
■ Zoom

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.

F2(Zoom)



F1 (BOX) .... Graph enlargement using box zoom

F2 (FACT) ..... Displays screen for specification of zoom factors

F3 (IN) .... Enlarges graph using zoom factors

F4 (OUT) .... Reduces graph using zoom factors

P.155

F5 (AUTO) .... Automatically sizes the graph so it fills the screen along the y-axis.

F6 (▷) .... Next menu

F6(▷)

P.155
P.156
P.157
P.158

F1 (ORIG) ..... Original size

F2 (SQR)....... Adjusts ranges so x-range equals y-range.

F3 (RND)....... Rounds coordinates at current pointer location.

F4 (INTG)...... Converts x- and y-axis values to integers.

F5 (PRE) .... After a zoom operation, returns View Window parameters to previous settings.

F6 (▷) .... Previous menu

•To use box zoom

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.

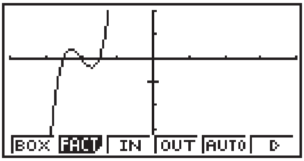
Example **To use box zoom to enlarge a portion of the graph $y = (x + 5)(x + 4)(x + 3)$**

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).

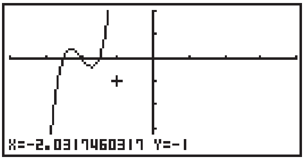
F2 (Zoom)



F1

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.

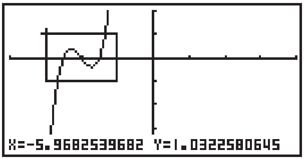
F1 (BOX)
◀ ~ ◀ EXE



```
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.

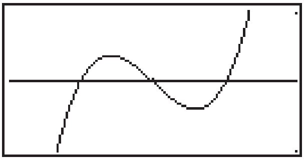
▲ ~ ▲ ◀ ~ ◀



```
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.

EXE



- 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

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.**

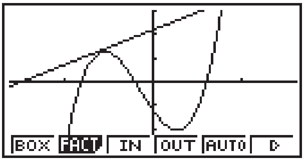
Y1 = (x + 4) (x + 1) (x – 3)
Y2 = 3x + 22

Use the following View Window parameters.

Xmin	**= –8**	**Ymin**	**= –30**
Xmax	**= 8**	**Ymax**	**= 30**
Xscale	**= 5**	**Yscale**	**= 10**

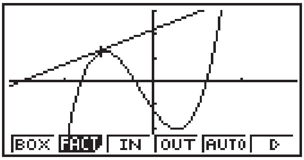
1. After graphing the functions, press F2 (Zoom), and the pointer appears on the screen.

F2 (Zoom)



2. Use the cursor keys (◀, ▶, ▲, ▼) to move the pointer to the location that you want to be the center of the new display.

◀ ~ ◀ ▲ ~ ▲



F2

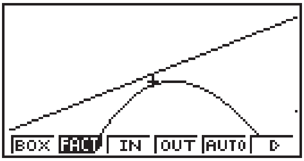
3. Press F2 (FACT) to display the factor specification screen, and input the factor for the x- and y-axes.

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.

EXIT
F3(IN)



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.

■ Using the Auto View Window

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**

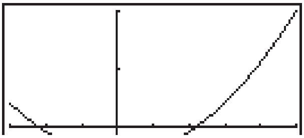
1. After graphing the function, press F2 (Zoom).

F2(Zoom)

F5

2. Press F5 (AUTO).

F5 (AUTO)



- You can use auto View Window with any type of graph.
- You cannot use auto View Window inside a program.
- You can use auto View Window with a graph produced by a multi-statement connected by ":", even if the multi-statement includes non-graph operations.
- When auto View Window is used in a statement that uses a display result command (◢) to draw a graph, auto View Window parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overdraw rules.

■ Adjusting the Ranges of a Graph (SQR)

This function makes the View Window *x*-range value the same as the *y*-range value. It is helpful when drawing circular graphs.

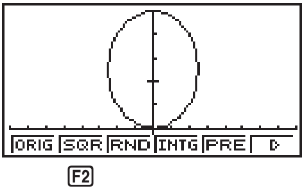
Example **To graph r = 5sin θ and then adjust the graph.**

Use the following View Window parameters.

Xmin = –8 **Ymin = –1**
Xmax = 8 **Ymax = 5**
Xscale = 1 **Yscale = 1**

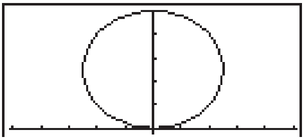
1. After drawing the graph, press F2 (Zoom) F6 (▷).

F2 (Zoom) F6 (▷)



2. Press F2 (SQR) to make the graph a circle.

F2 (SQR)



- You can use SQR with any type of graph.
- You cannot use SQR inside a program.
- You can use SQR with a graph produced by a multi-statement connected by ":", even if the multi-statement includes non-graph operations.
- When SQR is used in a statement that uses a display result command (◢) to draw a graph, Graph Adjust parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overwrite rules.

■ Rounding Coordinates (RND)

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.

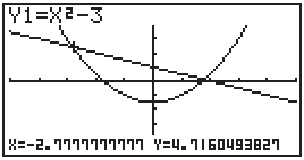
Example **To round the coordinates at the points of intersection of the two graphs drawn on page 146**

Use the same View Window parameters as in the example on page 146.

1. After graphing the functions, press F1 (Trace) and move the pointer to the first intersection.

F1(Trace)

▶ ~ ▶



Y1=X²-3

X=-2.7777777777 Y=4.7160493827

2. Press F2 (Zoom) F6 (▷).

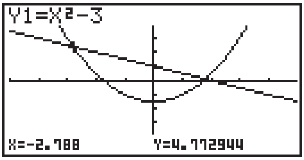
F2(Zoom)F6(▷)

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.

F3(RND)

F1(Trace)

▶ ~ ▶



Y1=X²-3

X=-2.788 Y=4.772944

- You can use RND with any type of graph.
- You cannot use RND inside a program.
- You can use RND with a graph produced by a multi-statement connected by ":", even if the multi-statement includes non-graph operations.
- When RND is used in a statement that uses a display result command (◢) to draw a graph, Rounding Coordinate parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overwrite rules.

■ Converting *x*- and *y*-axis Values to Integers (INTG)

This feature converts View Window values to the following, and redraws the graph with the current pointer position as the center point.

Xmin	=	center point –63.5	Ymin	=	center point –31.5
Xmax	=	center point +63.5	Ymax	=	center point +31.5
Xscale	=	10	Yscale	=	10

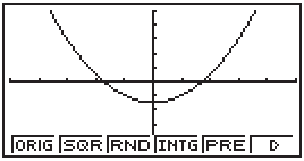
Example **To graph $y = x^2 - 3$ and then redraw it using INTG**

Use the following View Window parameters.

Xmin	**=**	**–5**	**Ymin**	**=**	**–10**
Xmax	**=**	**5**	**Ymax**	**=**	**10**
Xscale	**=**	**1**	**Yscale**	**=**	**2**

1. Press F2 (Zoom) F6 (▷) after drawing the graph.

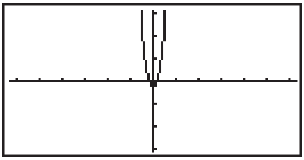
F2(Zoom)F6(▷)



F4

2. Press F4 (INTG).

F4(INTG)



- You can use INTG with any type of graph.
- You cannot use INTG inside a program.
- You can use INTG with a graph produced by a multi-statement connected by ":", even if the multi-statement includes non-graph operations.
- When INTG is used in a statement that uses a display result command (◢) to draw a graph, Integer parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overwrite rules.

■ Returning the View Window to Its Previous Settings

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

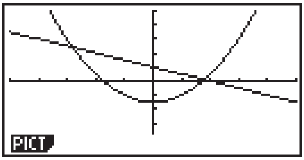
You can save up to six graphic image in picture memory for later recall. You can overdraw the graph on the screen with another graph stored in picture memory.

•To store a graph in picture memory

The following operation stores all points and lines currently on the screen.

Example **To store the graph drawn in the example on page 146 into picture memory Pic1**

OPTN



F1

F1(PICT)

F1

F1(STO)

F1

F1(Pic1)

- Storing a graph in a memory area (Pic1 through Pic6) that already contains a graph replaces the existing graph with a new one.

•To recall a graph from memory

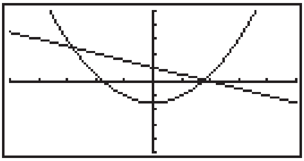
Example **To recall the graph stored in picture memory Pic1**

- In the GRAPH Mode:

  OPTN F1(PICT) F2(RCL)

F1

F1(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.7

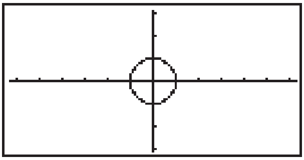
You can use the set-up screen to specify the memory contents of any picture memory area (Pict 1 through Pict 6) as the Background item. When you do, the contents of the corresponding memory area is used as the background of the graph screen.

- 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.**

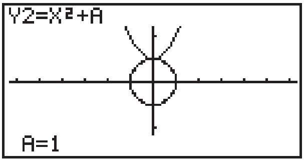
Recall the background graph.

($X^2 + Y^2 = 1$)



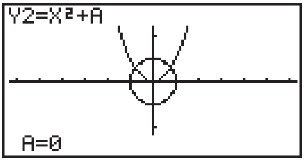
Draw the dynamic graph.

($Y = X^2 + 1$)



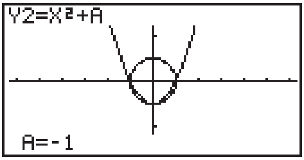
↓↑

($Y = X^2$)



↓↑

($Y = X^2 – 1$)

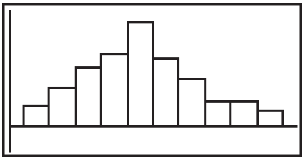


P.223
P.207

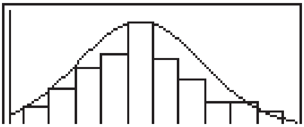
- See “14. Implicit Function Graphs” for details on drawing a circle graph, and “13. Dynamic Graph” for details on using the Dynamic Graph feature.

Example 2 **With a statistical histogram as the background, graph a normal distribution**

Recall the backgound graph.
(Histogram)



Graph the normal distribution.



P.283

- 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 the graph solve menu.

SHIFT F5 (G-Solv)

F1 (ROOT) .... Root

F2 (MAX) .... Maximum

F3 (MIN) .... Minimum

F4 (Y-ICPT) ... y-intercept

F5 (ISCT) ...... Intersections of two graphs

F6 (▷) .... Next menu

F6 (▷)

F1 (Y-CAL) .... y-coordinate for a given x-coordinate

F2 (X-CAL) .... x-coordinate for a given y-coordinate

F3 ($\int dx$) .... Integral for a given range

F6 (▷) .... Previous menu

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 = $x + 1$

Memory location Y2 = $x(x + 2)(x - 2)$

Use the View Window to specify the following parameters.

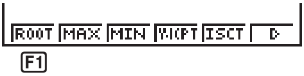
(A)	Xmin = –5	Ymin = –5	**(B)**	Xmin = –6.3	Ymin = –3.1
	Xmax = 5	Ymax = 5		Xmax = 6.3	Ymax = 3.1
	Xscale = 1	Yscale = 1		Xscale = 1	Yscale = 1

■ Determining Roots

Example **To determine the roots for $y = x(x + 2)(x - 2)$**

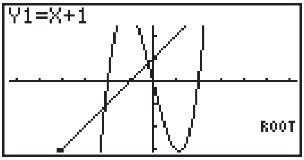
View Window: **(B)**

SHIFT F5(G-Solv)



F1(ROOT)

(This puts the unit into standby waiting for selection of a graph.)

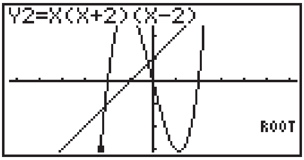


- A “ ■ ” cursor appears on the graph that has the lowest memory area number.

Specify the graph you want to use.

▼

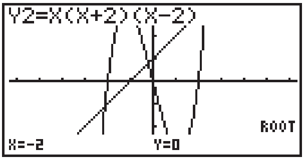
- Use ▲ and ▼ to move the cursor to the graph whose roots you want to find.



Determine the root.

EXE

- Roots are found starting from the left.

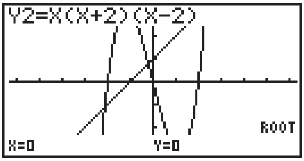


X=-2 Y=0

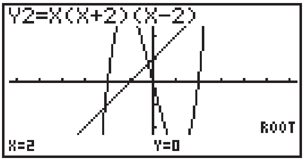
Search for the next root to the right.

▶

- If there is no root to the right, nothing happens when you press ▶.



▶



- 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 $y = x\ (x + 2)\ (x - 2)$**

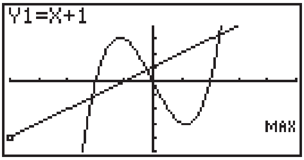
View Window: **(A)**

SHIFT F5(G-Solv)

F2

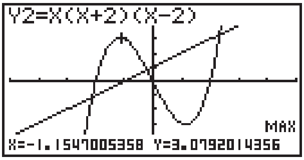
F2(MAX)

(This puts the unit into standby waiting for selection of a graph.)



Specify the graph and determine the maximum.

▼ EXE

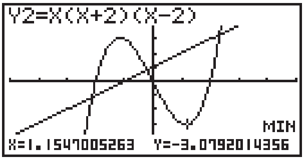


SHIFT F5(G-Solv)

F3

Specify the graph and determine the minimum.

F3(MIN) ▼ EXE



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 $y = x + 1$**

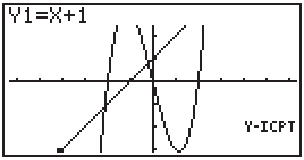
View Window: **(B)**

SHIFT F5(G-Solv)

F4

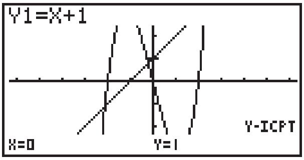
F4(Y-ICPT)

(This puts the unit into standby waiting for selection of a graph.)



Determine the *y*-intercept.

EXE



X=0 Y=1

- *y*-intercepts are the points that 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 A and Graph C.**

View Window: **(A)**

Graph A: $y = x + 1$

Graph B: $y = x\,(x + 2)\,(x - 2)$

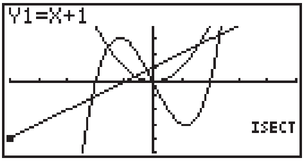
Graph C: $y = x^2$

SHIFT F5 (G-Solv)

F5

F5 (ISCT)

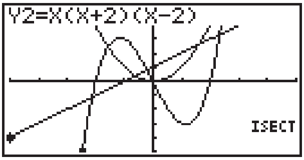
(This puts the unit into standby waiting for selection of a graph.)


Y1=X+1

Specify Graph A.

EXE

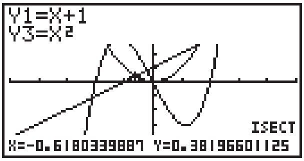
- Pressing EXE changes " ■ " into " ◆ " for specification of the first graph.


Y2=X(X+2)(X−2)

Specify the second graph (Graph C, here) to determine the points of intersection.

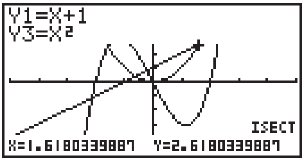
▼ EXE

- Use ▲ and ▼ to move " ■ " on the second graph.
- Intersections are found starting from the left.


Y1=X+1
Y3=X²
X=−0.6180339887 Y=0.3819660125

▶

- 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)

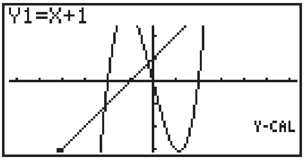
Example **To determine the y-coordinate for x = 0.5 and the x-coordinate for y = 3.2 in the graph $y = x (x + 2) (x – 2)$**

View Window: **(B)**

SHIFT F5 (G-Solv) F6 (▷)

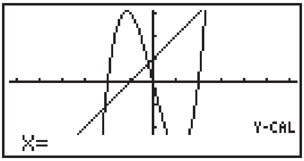
F1

F1 (Y-CAL)


Y1=X+1

Specify a graph.

▼ EXE



X=

- At this time, the unit waits for input of an x-coordinate value.

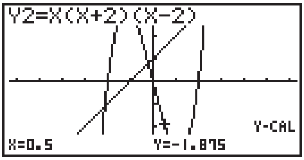
Input the x-coordinate value.

0 • 5


X=0.5_

Determine the corresponding y-coordinate value.

EXE


Y2=X(X+2)(X–2)

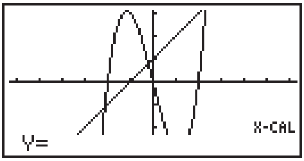
X=0.5 Y=–1.875

SHIFT F5 (G-Solv) F6 (▷)

F2

Specify a graph.

F2(X-CAL) ▼ EXE



Y=

- At this time, the unit waits for input of a *y*-coordinate value.

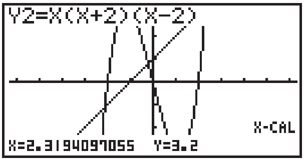
Input the *y*-coordinate value.

3 • 2

Y=3.2

Determine the corresponding *x*-coordinate value.

EXE



Y2=X(X+2)(X-2)

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=0.78539816339
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).

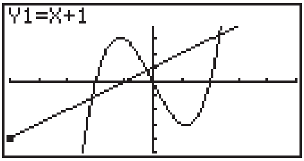
■ Determining the Integral for Any Range

Example $\int_{-1.5}^{0} x\,(x+2)\,(x-2)\,dx$

View Window: **(A)**

SHIFT F5 (G-Solv) F6 (▷)

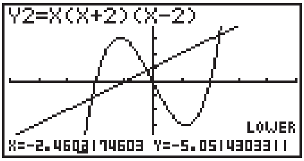
F3 (∫dx)
(Graph selection standby)



Select graph.

▼ EXE

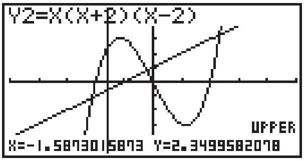
- The display is prompting input of the lower limit of the integration range.



X=-2.4603174603 Y=-5.0514303311

Move the pointer and input the lower limit.

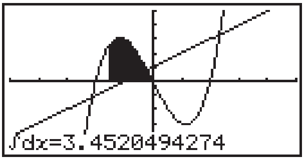
▶ ~ ▶ EXE



X=-1.5873015873 Y=2.3499582078

Input the upper limit and determine the integral.

▶ ~ ▶ EXE



∫dx=3.4520494274

- 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.

9-3 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

SHIFT F4 (Sketch)

P.188 F1 (Cls) .... Clears drawn line and point
P.176 F2 (Tang) .... Tangent
P.177 F3 (Norm) ...... Line normal to a curve
P.178 F4 (Inv) .... Inverse graph
F6 (▷) .... Next menu

- F2 (Tang), F3 (Norm), and F4 (Inv) appear only when you display the sketch menu while in the **GRAPH** and **TABLE Modes**.

F6 (▷)

P.179 F1 (PLOT) ..... Plot menu
P.182 F2 (LINE) ...... Line menu
P.184 F3 (Crcl) .... Circle
P.185 F4 (Vert) .... Vertical line
P.185 F5 (Hztl) .... Horizontal line
F6 (▷) .... Next menu

F6 (▷)

P.185 F1 (PEN) .... Freehand drawing
P.186 F2 (Text) .... Comment text
F6 (▷) .... Previous menu

RUN, PRGM Mode

SHIFT F4 (Sketch)

F5 (GRPH) .... Graph command menu

F6 (▷)

F6 (▷)

P.187 F3 (PIXL) .... Pixel menu

P.188 F4 (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.

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

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

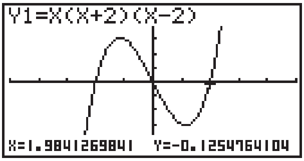
Example **To draw a line that is tangent to point (x = 2, y = 0) of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and press F2 (Tang).

   SHIFT F4 (Sketch) F2 (Tang)

2. Use the cursor keys (▲, ▼, ◀, ▶) to move the pointer the position of the point where you want to draw the line.

   ▶ ~ ▶

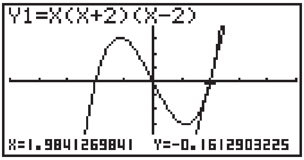


Y1=X(X+2)(X-2)

X=1.9841269841　Y=-0.1254764104

3. Press EXE to draw the line.

   EXE



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>

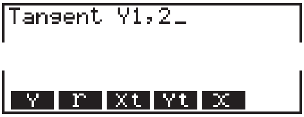
P.33

- 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. Enter the RUN Mode, display the sketch menu, and then perform the following input.

SHIFT F4 (Sketch) F2 (Tang)
VARS F4 (GRPH)
F1 (Y) 1 , 2

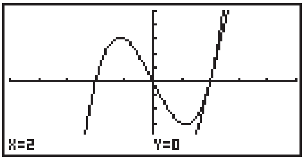


```
Tangent Y1,2_
```

F1

2. Press EXE to draw the tangent line.

EXE



■ Line Normal to a Curve

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

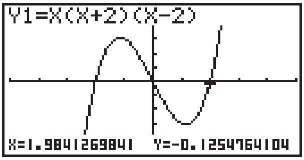
Example **To draw a line that is normal to the curve at point (x = 2, y = 0) of $y = x(x + 2)(x – 2)$**

1. After graphing the function, display the sketch menu and press F3 (Norm).

SHIFT F4 (Sketch) F3 (Norm)

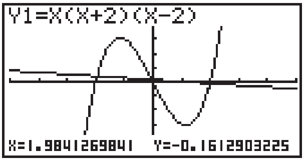
2. Use the cursor keys (▲, ▼, ◀, ▶) to move the pointer the position of the point where you want to draw the line.

▶ ~ ▶


Y1=X(X+2)(X-2)
X=1.9841269841 Y=-0.1254764104

3. Press EXE to draw the line.

EXE


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.33

- Use the variable data (VARS) menu to specify the function to be graphed.

■ Graphing an Inverse Function

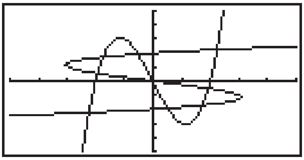
This function lets you graph the inverse of the function used to produce your original graph.

•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).

SHIFT F4 (Sketch) 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.33

- 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

When plotting points on a graph, first display the sketch menu and then press F6 (▷) F1 (PLOT) to display the plot menu.

F6(▷) F1(PLOT)

F1 (Plot) .... Plot a point
F2 (Pl•On) ..... Plot point at specific coordinates
F3 (Pl•Off) ..... Delete point at specific coordinates
F4 (Pl•Chg) ... Switch status of point at specific coordinates

•To plot points in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

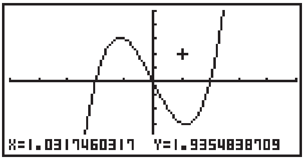
Example **To plot a point on the graph of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and perform the following operation to cause the pointer to appear on the graph screen.

   SHIFT F4(Sketch) F6 (▷) F1 (PLOT) F1(Plot)

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.

▶ ~ ▶ ▲ ~ ▲
EXE



X=1.0317460317 Y=1.9354838709

- The current x- and y-coordinate values are assigned respectively to variables X and Y.

•To plot points in the RUN or PRGM Mode

The following is the syntax for plotting points in these modes.

Plot <*x*-coordinate>, <*y*-coordinate>

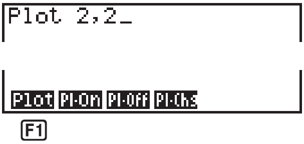
Example **To plot a point at (2, 2)**

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.

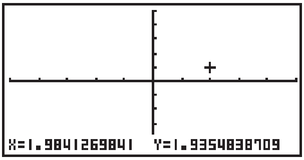
SHIFT F4(Sketch) F6(▷)
F1(PLOT) F1(Plot) 2 , 2



```
Plot 2,2_
```

2. Press EXE and the pointer appears on the display. Press EXE again to plot a point.

EXE EXE



```
X=1.9841269841   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

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 a graph, display the sketch menu and then perform the following operation to make the pointer appear at the center of the screen.

   SHIFT F4(Sketch) F6(▷) F1(PLOT) F2(Pl•On)

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

To draw a line on a graph, first display the sketch menu and then press F6 (▷) F2 (LINE) to display the line menu.

F6 (▷) F2 (LINE)

F1 (Line) .... Draw a line between two plotted points

F2 (F•Line) .... Draw a line

•To draw a line between two plotted points in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

Example **To draw a line between the two points of inflection on the graph of $y = x(x + 2)(x - 2)$**

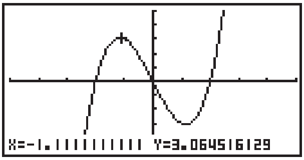
Use the same View Window parameters as in the example on page 176.

1. After graphing the function, display the sketch menu and perform the following operation to cause the pointer to appear on the graph screen.

SHIFT F4 (Sketch) F6 (▷) F1 (PLOT) F1 (Plot)

2. Use the cursor keys (▲, ▼, ◀, ▶) to move the pointer to one of the points of inflection and press EXE to plot it.

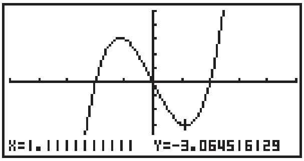
◀ ~ ◀ ▲ ~ ▲
EXE



X=-1.1111111111 Y=3.064516129

3. Use the cursor keys to move the pointer to the other point of inflection.

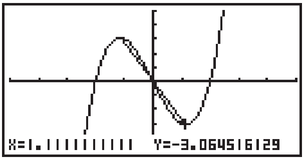
▶ ~ ▶ ▼ ~ ▼



X=1.1111111111 Y=-3.064516129

4. Display the sketch menu and perform the following operation to draw a line between the two points.

SHIFT F4(Sketch) F6(▷)
F2(LINE) F1(Line)



X=1.1111111111 Y=-3.064516129

•To draw a line in the STAT, GRAPH, TABLE, RECUR and CONICS Modes

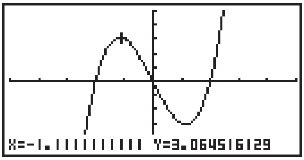
Example **To draw a line between two points of inflection on the graph of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and perform the following operation to cause the pointer to appear on the graph screen.

SHIFT F4(Sketch) F6(▷) F2(LINE) F2(F•Line)

2. Use the cursor keys (▲, ▼, ◀, ▶) to move the pointer to one of the points of inflection and press EXE.

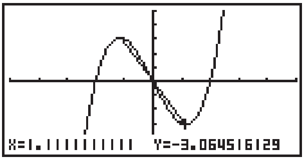
◀ ~ ◀ ▲ ~ ▲
EXE



X=-1.1111111111 Y=3.064516129

3. Use the cursor keys to move the pointer to the other point of inflection and press EXE to draw the line.

▶ ~ ▶ ▼ ~ ▼
EXE



X=1.1111111111 Y=-3.064516129

•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

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

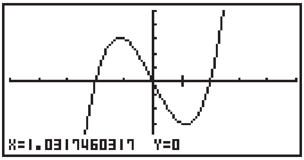
Example **To draw a circle with a radius of R = 1 centered at point (1, 0) on the graph of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and perform the following operation to cause the pointer to appear on the graph screen.

   SHIFT F4(Sketch) F6(▷) F3(Crcl)

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.

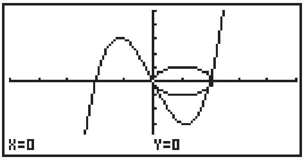
   ▶ ~ ▶
   EXE



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.

   ◀ ~ ◀
   EXE



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

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

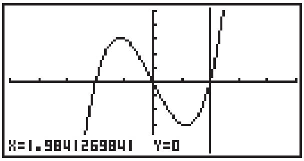
Example **To draw a vertical line on the graph of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and perform the following operation to display the pointer and draw a vertical line through its current location.

   SHIFT F4 (Sketch) F6 (▷) F4 (Vert)

2. Use the ◀ and ▶ cursor keys to move the line left and right, and press EXE to draw the line at the current location.

   ▶ ~ ▶
   EXE



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

This function lets you make freehand drawings on a graph, just as if you were using a pen.

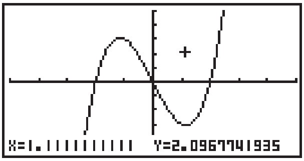
- Freehand drawing is available only in the **STAT, GRAPH, TABLE, RECUR** and **CONICS Modes**.

Example **To draw on the graph of $y = x(x + 2)(x - 2)$**

1. After graphing the function, display the sketch menu and perform the following operation to cause the pointer to appear on the graph screen.

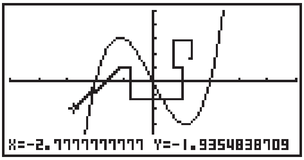
   SHIFT F4(Sketch) F6(▷) F6(▷) F1(PEN)

2. Use the cursor keys (▲, ▼, ◀, ▶) to move the pointer to the location where you want to start drawing and press EXE to plot it.



X=1.1111111111 Y=2.0967741935

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

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 graphing the function, display the sketch menu and perform the following operation to cause the pointer to appear on the graph screen.

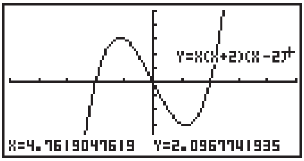
   SHIFT F4(Sketch) F6(▷) F6(▷) F2(Text)

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)



•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.

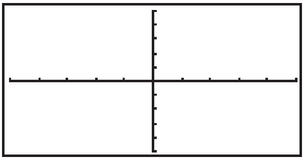
  A~Z, r, θ, space, 0~9, ., +, –, ×, ÷, (–), EXP, π, Ans, ⏎, (,), [,], {, }, comma, →, x^2, ^, log, In, $\sqrt{\ }$, $^x\sqrt{\ }$, 10^x, e^x, $^3\sqrt{\ }$, x^{-1}, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$
- A newline operation cannot be performed when inserting comment text. To input multiple lines, you have to perform the above comment text insert operations more than once.

■ Turning Pixels On and Off

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.

F6(▷)F6(▷)F3(PIXL)

F1 (On) .... Turn specified pixel on

F2 (Off) .... Turn specified pixel off

F3 (Chg) .... Switch status of specified pixel

•To turn pixels on and off

- **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

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 (Syn ERROR).
- Pixel operations are valid only within the allowable line and column ranges.

■ Clearing Drawn Lines and Points

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.

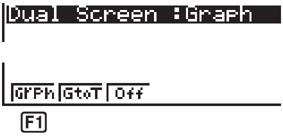
- You should be familiar with the contents of “8-3 Graph Function Operations” before reading this chapter.

11-1 Before Using Dual Graph

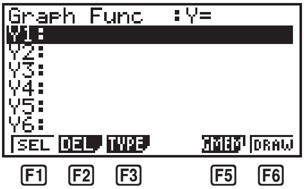
P.8

From the Main Menu, enter the **GRAPH** Mode and set the Dual Screen setting to “Graph”.

SHIFT SETUP ▽ ▽ F1(Grph)


Dual Screen :Graph

EXIT


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

P.126

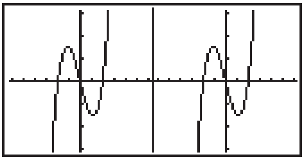
- For further details about the function key menu at the bottom of the display, see “8-1 Before Trying to Draw a Graph”.
- 8,192 bytes of memory are used whenever you set the Dual Screen setting to “Graph”.

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* containing 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

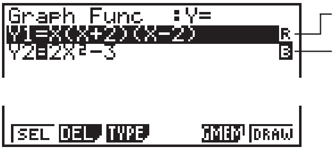
Actual graph drawing is done here.



Inactive Screen

Use this screen to make copies of active screen graphs, and for the result of Zoom operations. You can also set different View Window parameters for the active and inactive screens.

- 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

If you redraw graphs in the situation shown above, the function marked “R” is drawn as the inactive graph, while “B” is drawn using both sides of the display.

If you press F1 (SEL), the “R” and “B” indicators are cleared, and the graphs are drawn as active graphs.

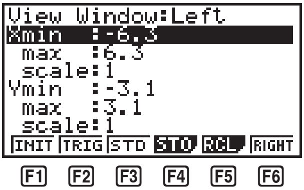
11-2 Specifying the Left and Right View Window Parameters

You can specify different View Window parameteres 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.

SHIFT F3 (V-Window)



```
View Window:Left
Xmin  :-6.3
 max  :6.3
 scale:1
Ymin  :-3.1
 max  :3.1
 scale:1
```

P.129	F1 (INIT)	Initialization of View Window values
P.129	F2 (TRIG)	Initialization of View Window values to match trigonometric units
P.130	F3 (STD)	View Window standard settings
P.130	F4 (STO)	Store settings in memory
P.130	F5 (RCL)	Recall settings from memory
	F6 (RIGHT) F6 (LEFT) ...	Swap active (left) screen and inactive (right) screen View Window settings

P.127
- 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

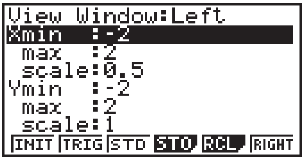
11-3 Drawing a Graph in the Active Screen

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:



```
View Window:Left
Xmin  :-2
 max  :2
 scale:0.5
Ymin  :-2
 max  :2
 scale:1
```

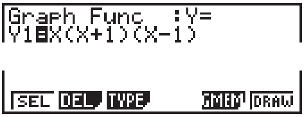
Input the function.

X,θ,T (X,θ,T + 1)
(X,θ,T - 1)

```
Graph Func  :Y=
Y1=X(X+1)(X-1)_
```

Store the function.

EXE

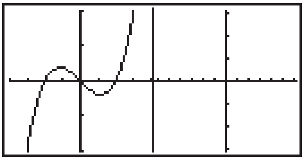


```
Graph Func  :Y=
Y1=X(X+1)(X-1)
```

F6

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.

OPTN

F1 F2 F3

F1 (COPY) .... Copies active graph to inactive screen

F2 (SWAP) .... Switches active screen and inactive screen

F3 (PICT) ...... Picture function

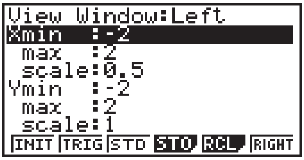
P.159

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**

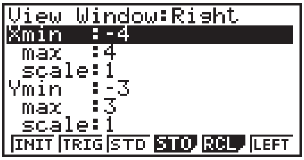
Use the following View Window parameters:

Active (Left) Screen
View Window parameters



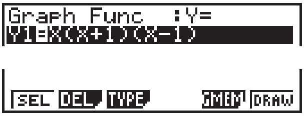
View Window:Left
Xmin :-2
max :2
scale:0.5
Ymin :-2
max :2
scale:1

Inactive (Right) Screen
View Window parameters



View Window:Right
Xmin :-4
max :4
scale:1
Ymin :-3
max :3
scale:1

Assume that the function being graphed is stored in memory area Y1.

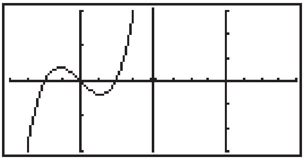


Graph Func :Y=
Y1=X(X+1)(X−1)

F6

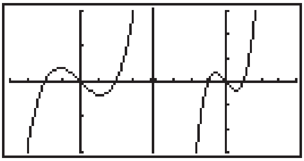
Draw the graph in the active screen.

F6(DRAW)



Copy the graph to the inactive (right) screen.

OPTN F1(COPY)



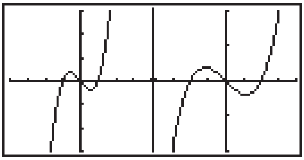
- The graph is reproduced using the inactive screen View Window parameters.

Switching the Contents of the Active and Inactive Screens

Example **To switch the screens produced by the preceding example**

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

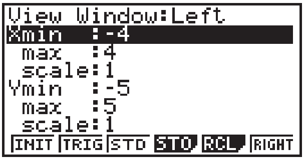
Example **To draw the graphs of the following functions on the screens noted:**

Active Screen: $y = x(x + 1)(x - 1)$

Inactive Screen: $y = 2x^2 - 3$

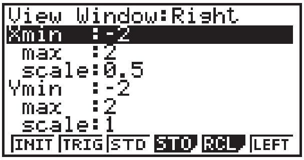
Use the View Window parameters shown below.

Active (Left) Screen
View Window parameters



```
View Window:Left
Xmin  :-4
 max  :4
 scale:1
Ymin  :-5
 max  :5
 scale:1
INIT TRIG STD STO RCL RIGHT
```

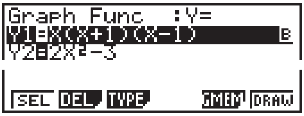
Inactive (Right) Screen
View Window parameters



```
View Window:Right
Xmin  :-2
 max  :2
 scale:0.5
Ymin  :-2
 max  :2
 scale:1
INIT TRIG STD STO RCL LEFT
```

Assume that the functions being graphed are stored in memory areas Y1 and Y2.

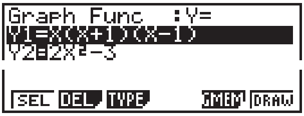
Select the function for the graph that you want to end up in the inactive (right) screen.



```
Graph Func  :Y=
Y1=X(X+1)(X-1)      B
Y2=2X²-3
```

F1

F1(SEL)

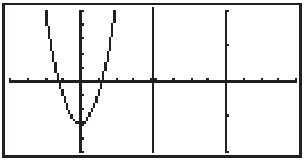


```
Graph Func  :Y=
Y1=X(X+1)(X-1)
Y2=2X²-3
```

F6

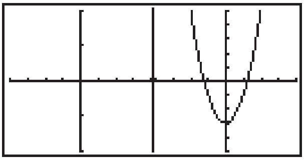
Draw the graph in the active screen.

F6(DRAW)



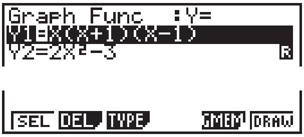
Swap the screens so the graph is on the inactive (right) screen.

OPTN F2(SWAP)



Select the function for the graph that you want in the now-empty active (left) screen.

AC F1(SEL)

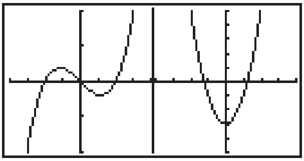


```
Graph Func  :Y=
Y1=X(X+1)(X-1)
Y2=2X²-3            R
```

F6

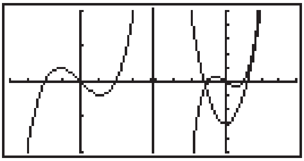
Draw the graph.

F6(DRAW)



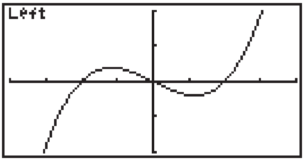
- At this point, you could perform a copy operation and superimpose the active graph over the inactive graph.

OPTN F1(COPY)

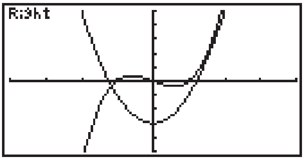


- Pressing SHIFT F6 (G ↔ T) lets you switch between display of the active and inactive graphs, using the entire display for each.

SHIFT F6(G ↔ T)



SHIFT F6(G ↔ T)



SHIFT F6(G ↔ T)

```
Graph Func  :Y=
Y1=X(X+1)(X-1)      B
Y2=2X²-3            R
```

Other Graph Functions with Dual Graph

P.146

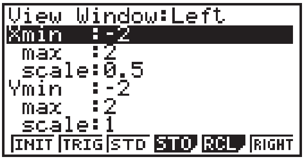
After drawing a graph using Dual Graph, you can use the trace, zoom, sketch and scroll functions. Note, however, that these functions are available only for the active (left) graph. For details on using these functions, see “8-6 Other Graphing Functions”.

- 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.

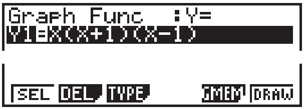
Example 1 **To use box zoom to enlarge the graph of $y = x (x + 1) (x - 1)$**

Use the following View Window parameters for the active graph.



View Window:Left
Xmin :-2
max :2
scale:0.5
Ymin :-2
max :2
scale:1

Assume that the function is already stored in memory area Y1.

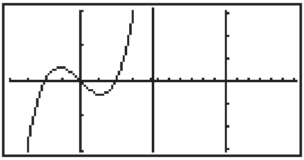


Graph Func :Y=
Y1=X(X+1)(X-1)

F6

Draw the graph.

F6(DRAW) or EXE

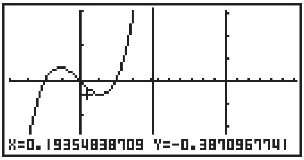


Specify one corner of the area to be enlarged.

SHIFT F2(Zoom) F1(BOX)

▼ ~ ▼ ▶ ~ ▶ EXE

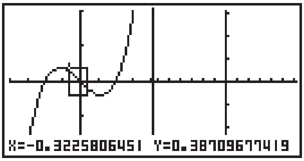
- Use the cursor keys to move the pointer to the location you want.



X=0.193548387O9 Y=-0.3870967741

Move the pointer to the other corner of the area to be enlarged.

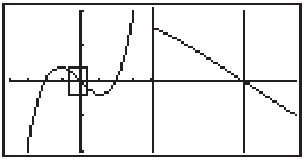
▲ ~ ▲◀ ~ ◀



X=-0.3225806451 Y=0.38709677419

Enlarge the graph.

EXE



- The View Window parameters of the inactive screen are always changed by a Zoom operation, so if there is a graph already on the inactive screen, it is cleared before the result of the Zoom operation is drawn there.

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.

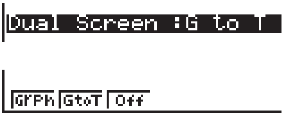
12-1 Before Using Graph-to-Table

P.8

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**".

SHIFT SETUP

▼ ▼ F2 (G to T)

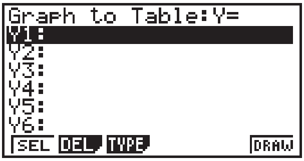


Dual Screen :G to T

F2

2. Press EXIT and the Graph-to-Table menu appears.

EXIT



Graph to Table:Y=

Y1:

Y2:

Y3:

Y4:

Y5:

Y6:

P.126

- 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.

P.6

•To store graph pointer coordinates in a table

- If the Derivative item in the set up screen is turned on, the following operation also stores derivatives in the table.

Example **To store the points of intersection and the coordinates for the following graphs where X = 0:**

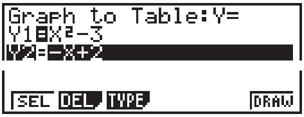
Y1 = x^2 – 3

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.

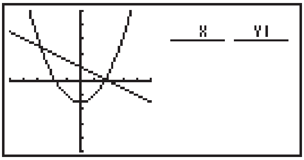


Graph to Table:Y=
Y1■X²-3
Y2■-X+2

F6

2. Press F6 (DRAW) to draw the graph in the left half of the screen.

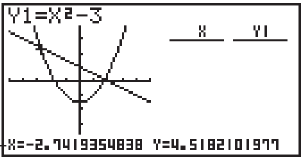
F6 (DRAW) or EXE



3. Press F1 (Trace) and then use ▶ to move the pointer to the first intersection.

F1 (Trace)

▶~▶



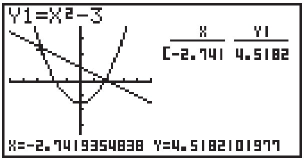
Y1=X²-3

x/y-coordinate value

X=-2.7419354838 Y=4.5182101977

4. Press EXE to store the coordinates of the pointer location in the table on the right side of the screen.

EXE



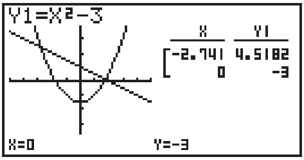
Y1=X²-3

X	Y1
-2.741	4.5182

X=-2.7419354838 Y=4.5182101977

5. Use ▶ to move the pointer the point where X = 0 and then press EXE to store the coordinates in the table.

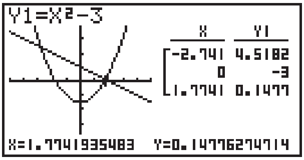
▶~▶
EXE



X	Y1
-2.741	4.5182
0	-3

X=0 Y=-3

▶~▶
EXE

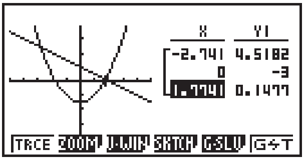


X	Y1
-2.741	4.5182
0	-3
1.7741	0.1477

X=1.7741935483 Y=0.1477627471 4

6. Pressing AC causes the cursor (■) to appear in the table. You can then use the cursor keys to move the cursor around the table and check its values. Press AC again to return the pointer to the graph screen.

AC



X	Y1
-2.741	4.5182
0	-3
1.7741	0.1477

•To save numeric table values in a list file

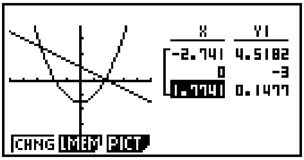
You can save columns of values into list files. Up to six values can be stored in a list file.

- The cursor 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.

OPTN



X	Y1
-2.741	4.5182
0	-3
1.7741	0.1477

F1 F2 F3

F1 (CHNG) .... Changes the active screen (between left and right)
F2 (LMEM) .... Save table column to list file.
F3 (PICT) ...... Save graph data to graph memory.

P.159

2. Press F2 (LMEM).

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”.

P.263

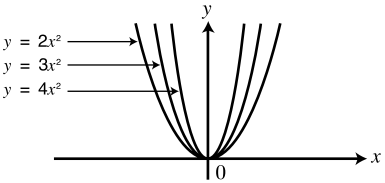
12-3 Graph-to-Table Precautions

- 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 cursor is blinking in the table. To clear the cursor 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

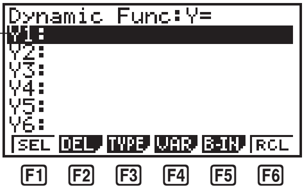
Dynamic Graph

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.



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

Selected memory area
Press ▽ and △ to move.

F1 (SEL) .... Dynamic Graph draw/non-draw status
F2 (DEL) .... Function delete
F3 (TYPE) ..... Function type specification
F4 (VAR) .... Coefficient menu
F5 (B•IN) .... Menu of built-in functions*
F6 (RCL) .... Recall and execution of Dynamic Graph conditions and screen data

P.210
P.218

* The built-in function menu contains the following seven functions.

•$Y=AX+B$
•$Y=A(X+B)^2+C$
•$Y=AX^2+BX+C$
•$Y=AX^\wedge 3+BX^2+CX+D$
•$Y=A\sin(BX+C)$
•$Y=A\cos(BX+C)$
•$Y=A\tan(BX+C)$

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.

P.132

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, an error occurs "No Variable". If this happens, press AC to clear the error.

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

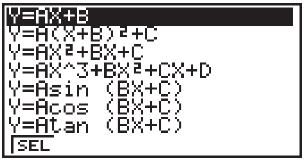
Example **To use Dynamic Graph to graph y = A (x–1)^2 –1 as the value of A changes from 2 to 5 in increments of 1**

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.

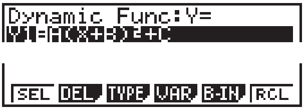
F5 (B•IN)



```
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

▼ F1 (SEL)

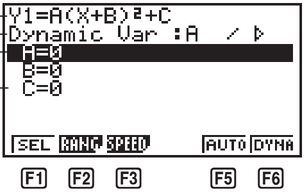


```
Dynamic Func:Y=
Y1=A(X+B)²+C
```

F4

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

F1 (SEL) .... Selects dynamic coefficient

F2 (RANG) .... Dynamic coefficient range settings

F3 (SPEED) ... Dynamic Graph drawing speed

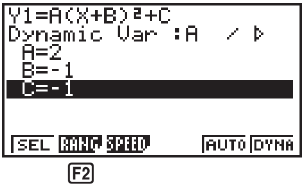
F5 (AUTO) ..... Automatic setting of end and pitch values to match coefficient values

F6 (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.

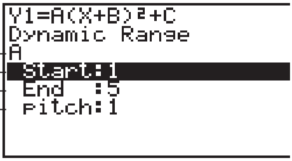
2 EXE
(−) 1 EXE
(−) 1 EXE


Y1=A(X+B)²+C
Dynamic Var :A
A=2
B=-1
C=-1

- 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)



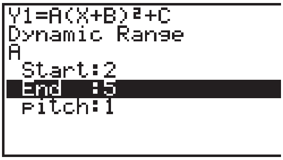
```
Y1=A(X+B)²+C
Dynamic Range
A
 Start:1
 End  :5
 pitch:1
```

Dynamic coefficient
Start value
End value
Increment

- The range you set remains in effect until you change it.

5. Change the range settings.

2 EXE

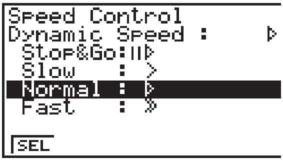


```
Y1=A(X+B)²+C
Dynamic Range
A
 Start:2
 End  :5
 pitch:1
```

EXIT

- If you want to change the Dynamic Graph speed, press F3 (SPEED).

F3 (SPEED)



```
Speed Control
Dynamic Speed :     ▷
 Stop&Go:||▷
 Slow   : >
 Normal : ▷
 Fast   : »
```

F1

P.216

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 three different variations for Dynamic Graphing.

- 10-time continuous drawing
- Continuous drawing
- Stop and go drawing

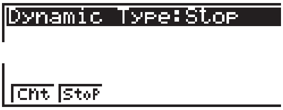
■ 10-time Continuous Drawing

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 210)**

Display the coefficient value specification display and specify **Stop** as the draw type.

SHIFT SET UP F2 (Stop)



Dynamic Type:Stop

F2

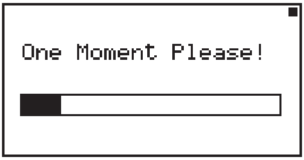
EXIT

Y1=A(X+B)²+C
Dynamic Var :A

F6

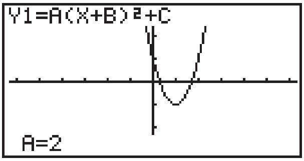
Start drawing of the Dynamic Graph.

F6 (DYNA)



One Moment Please!

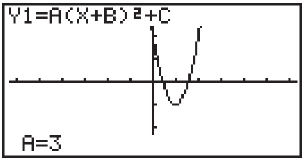
↓



Y1=A(X+B)²+C

A=2

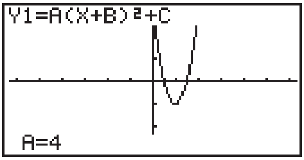
Graph is drawn 10 times. ↓↑



Y1=A(X+B)²+C

A=3

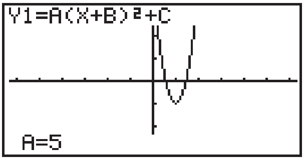
↓↑



Y1=A(X+B)²+C

A=4

↓↑



Y1=A(X+B)²+C

A=5

- 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).

P.7

- 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.

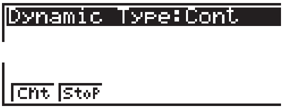
Continuous Drawing

When the Dynamic Graph draw type (Dynamic Type) is set to continuous (**Cont**), 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 210)**

Display the coefficient value specification display, and specify **Cont** as the draw type.

SHIFT SET UP F1(Cnt)


Dynamic Type:Cont

F1

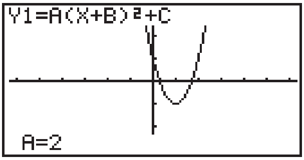
EXIT


Y1=A(X+B)²+C
Dynamic Var :A

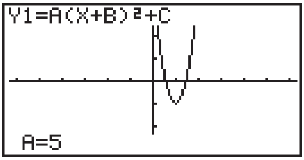
F6

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).
- 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.

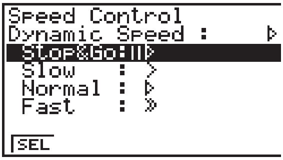
Stop & Go Drawing

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 210)**

Display the coefficient value specification display and press F3 (SPEED).
Use ▲ and ▼ to select **STOP & GO** (⦀▷) and press F1 (SEL).

F3(SPEED)▲▲



```
Speed Control
Dynamic Speed :     ▷
 Stop&Go:⦀▷
 Slow   : >
 Normal : ▷
 Fast   : »

SEL
```

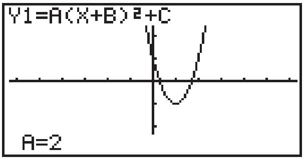
F1(SEL)EXIT

```
Y1=A(X+B)²+C
Dynamic Var :A   ⁄⦀▷

SEL RANG SPEED      AUTO DYNA
```

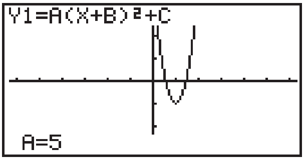
F6

Start drawing of the Dynamic Graph.

F6(DYNA)



EXE ⋮ ↓ ↑ ⋮ EXE



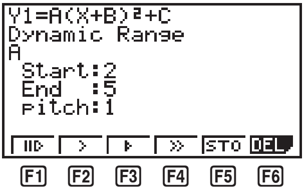
- Pressing AC while the Dynamic Graph is being drawn changes to the drawing speed setting display. The draw operation is suspended at this time, and you can view the graph by pressing SHIFT F6 (G ↔ T).

•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.

AC



Y1=A(X+B)²+C
Dynamic Range
A
 Start:2
 End :5
 pitch:1

F1 (II▷)........... Stop & Go

F2 (>)............. Slow (1/2 Normal)

F3 (▷)............ Normal (default speed)

P.218 F4 (≫)............ Fast (double Normal)

F5 (STO) .... Store graph conditions and screen data in Dynamic Graph memory

P.219 F6 (DEL)........ Delete Dynamic Graph screen data

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.

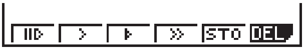
The following is all of the data that makes up a set.

- Graph functions (up to 20)
- Dynamic Graph conditions
- Set up screen settings
- View Window contents
- Dynamic Graph screen

●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.

AC



F5

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.

●To recall data from Dynamic Graph memory

1. Display the Dynamic Graph function list.

F6

2. Press F6 (RCL) to recall all the data stored in Dynamic Graph memory.
   - Data recalled from Dynamic Graph replaces the calculator's current graph functions, draw conditions, and screen data. The previous data is lost when it is replaced.

•To delete Dynamic Graph screen data

AC F6(DEL)

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
Xmax = 42
Xscale = 5

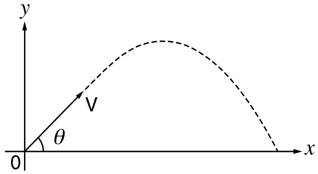
Ymin = –1
Ymax = 16
Yscale = 2

With the initial velocity defined as V and the angle defined as θ, the parabolas can be obtained using the following expressions.

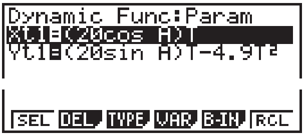
X = Vcos θ T

Y = Vsin θ T – (1/2)gT^2

g = 9.8 meters per second



1. Input the functions, making sure to specify them a parametric (Param) type.



```
Dynamic Func:Param
Xt1=(20cos A)T
Yt1=(20sin A)T-4.9T²
```

F4

2. Display the coefficient menu and specify the dynamic coefficient.

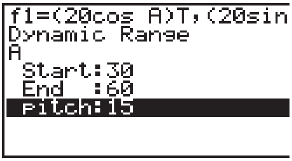
F4(VAR) 3 0 EXE

```
f1=(20cos A)T,(20sin
Dynamic Var :A   ⁄ ▷
 A=30
```

F2

3. Display the coefficient range menu and specify the range values.

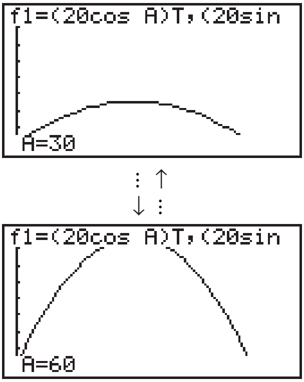
F2(RANG)
3 0 EXE 6 0 EXE 1 5 EXE



```
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

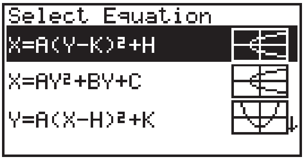
You can graph any one of the following types of implicit functions using the calculator’s built-in functions.

- 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

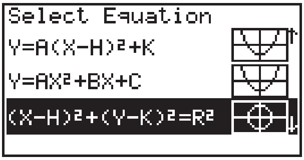
Example 1 **To graph the circle $(X-1)^2 + (Y-1)^2 = 2^2$**

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.

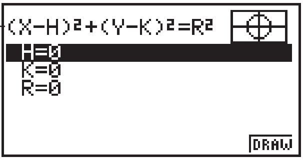
▼▼▼▼



```
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.

EXE

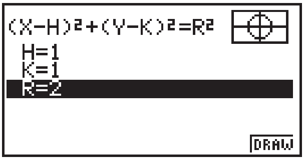


```
(X-H)²+(Y-K)²=R²
 H=0
 K=0
 R=0
```

- 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



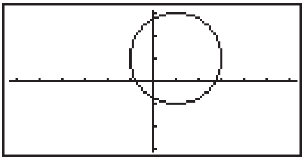
```
(X-H)²+(Y-K)²=R²
 H=1
 K=1
 R=2
```

F6

- You can also use ▲ and ▼ to highlight a variable and then input a value.

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

F6 (DRAW)



P.155

- 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.

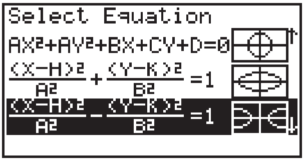
Xmin = –8 **Ymin** = –10

Xmax = 12 **Ymax** = 10

Xscale = 1 **Yscale** = 1

1. Select the function whose graph you want to draw.

▼ ▼ ▼ ▼ ▼ ▼ ▼



Select Equation

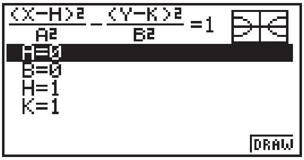
$AX^2+AY^2+BX+CY+D=0$

$\frac{(X-H)^2}{A^2} + \frac{(Y-K)^2}{B^2} = 1$

$\frac{(X-H)^2}{A^2} - \frac{(Y-K)^2}{B^2} = 1$

2. Press EXE and the variable input screen appears.

EXE



$\frac{(X-H)^2}{A^2} - \frac{(Y-K)^2}{B^2} = 1$

A=0

B=0

H=1

K=1

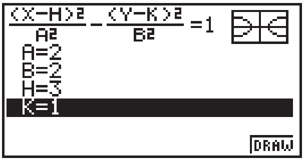
3. Assign values to each variable.

2 EXE

2 EXE

3 EXE

1 EXE



$\frac{(X-H)^2}{A^2} - \frac{(Y-K)^2}{B^2} = 1$

A=2

B=2

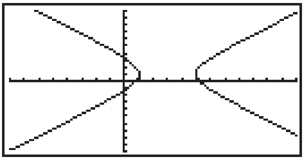
H=3

K=1

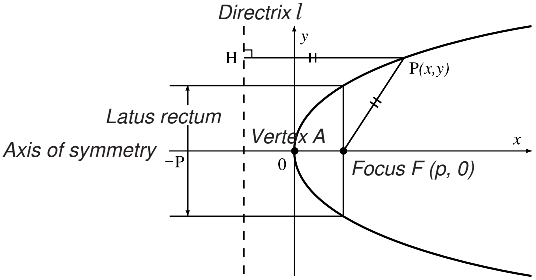
F6

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

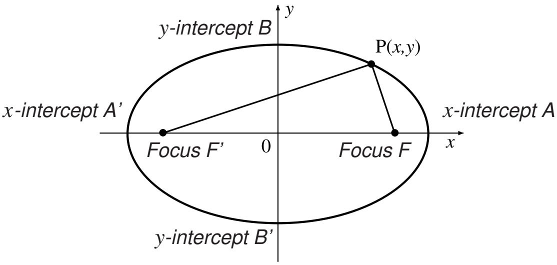
F6 (DRAW)



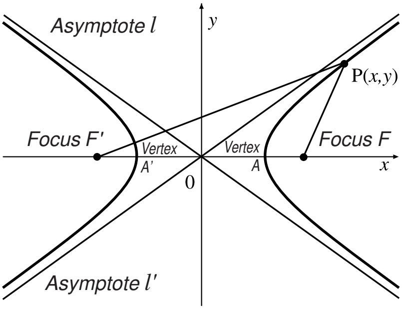
- A parabola is the locus of points equidistant from fixed line *l* and fixed point F not on the line. Fixed point F is the “focus,” fixed line *l* is the “directrix,” the horizontal line that passes through the focus directrix is the “axis of symmetry,” the length of a straight line that intersects 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 i and i' , 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.

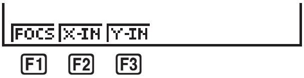
- Focus/vertex calculation
- Latus rectum calculation
- Center/radius calculation
- x-/y-intercept calculation
- Directrix/axis of symmetry drawing and analysis
- Asymptote drawing and analysis

After graphing an implicit function, press F5 (G-Solv) to display the Graph Analysis Menu.

- Parabolic Graph Analysis
  - F1 (FOCS) .... Determines the focus.
  - F2 (SYM) .... Draws the axis of symmetry.
  - F3 (DIR) .... Draws the directrix.
  - F4 (VTX) .... Determines the vertex.
  - F5 (LEN) .... Determines the latus rectum.

- Circle Graph Analysis
  - F1 (CNTR) .... Determines the center.
  - F2 (RADS) .... Determines the radius.

- Ellipse Graph Analysis
  - F1 (FOCS) .... Determines the focus.
  - F2 (X-IN) .... Determines the x-intercept.
  - F3 (Y-IN) .... Determines the y-intercept.



- Hyperbolic Graph Analysis
  - F1 (FOCS) .... Determines the focus.
  - F2 (X-IN) .... Determines the x-intercept.
  - F3 (Y-IN) .... Determines the y-intercept.
  - F4 (VTX) .... Determines the vertex.
  - F5 (ASYM) .... Determines 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

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

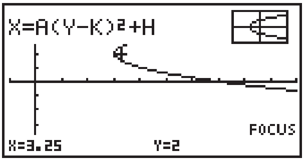
Xmax = 10 **Ymax** = 5

Xscale = 1 **Yscale** = 1

F5 (G-Solv)

F1

F1 (FOCS)
(Calculates the focus.)

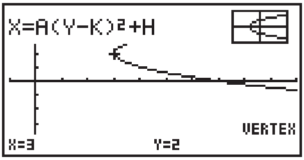


X=3.25 Y=2

F5 (G-Solv)

F4

F4 (VTX)
(Calculates the vertex.)



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

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

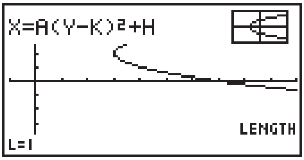
Xscale = 1 **Yscale** = 1

F5 (G-Solv)

F5

F5 (LEN)

(Calculates the latus rectum.)



X=A(Y−K)²+H

LENGTH

L=1

•To calculate the center and radius

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**

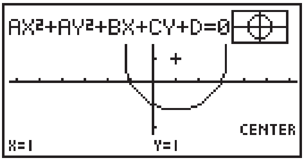
Xscale = 1 **Yscale = 1**

F5 (G-Solv)

F1

F1 (CNTR)

(Calculates the center.)



AX²+AY²+BX+CY+D=0

CENTER

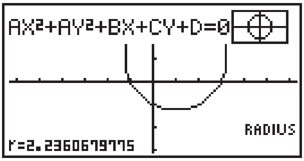
X=1 Y=1

F5 (G-Solv)

F2

F2 (RADS)

(Calculates the radius.)



AX²+AY²+BX+CY+D=0

RADIUS

r=2.2360679775

•To calculate the x- and y-intercepts

Example **To determine the x- and y-intercepts for the hyperbola**

$$\frac{(X-1)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

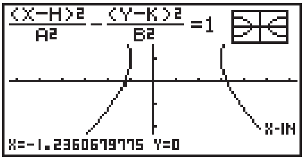
Use the following View Window parameters.

Xmin	**= –6.3**	**Ymin**	**= –3.1**
Xmax	**= 6.3**	**Ymax**	**= 3.1**
Xscale	**= 1**	**Yscale**	**= 1**

F5 (G-Solv)

F2

F2 (X-IN)
(Calculates the x-intercept.)

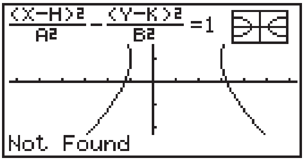


X=-1.2360679775 Y=0

F5 (G-Solv)

F3

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

Example **To draw the axis of symmetry and directrix for the parabola** **$X = 2(Y-1)^2 + 1$**

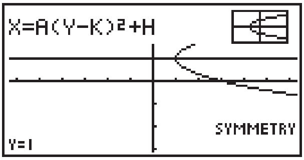
Use the following View Window parameters.

Xmin	**= –6.3**	**Ymin**	**= –3.1**
Xmax	**= 6.3**	**Ymax**	**= 3.1**
Xscale	**= 1**	**Yscale**	**= 1**

F5 (G-Solv)

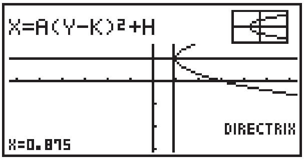
F2

F2 (SYM)
(Draws the axis of symmetry.)



F5 (G-Solv)

F3 (DIR)
(Draws the axis of directrix.)



●To draw and analyze the asymptotes

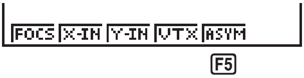
Example **To draw the asymptotes for the hyperbola**

$$\frac{(X-1)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

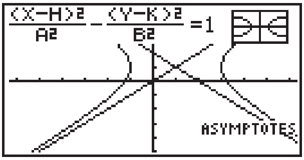
Use the following View Window parameters.

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 graph analysis result values.
- 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.

14-4 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 $B = 0$

- 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.

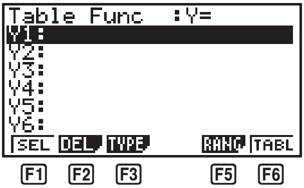
Chapter 15

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.



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

F1 (SEL) .... Numeric table generation/non-generation status

F2 (DEL) .... Function delete

F3 (TYPE) ..... Function type specification

F5 (RANG) .... Table range specification screen

F6 (TABL) ...... Start numeric table generation

- Note that the item for function key F5 (RANG) 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**

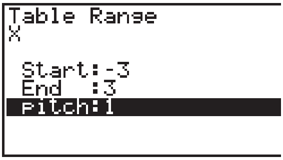
  With this method, you substitute the values contained in a previously created list for the value of the variable.

•To generate a table using a table range

Example **To generate a table as the value of variable x change 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. The following is the meaning of each of the numeric table range parameters.

Start .... Variable x start value

End .... Variable x end value

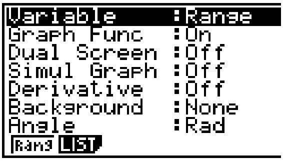
pitch .... Variable x value change

After specifying the table range, press EXIT to return to the function list.

•To generate a table using a list

Example **To generate a table using the values in List 6**

SHIFT SETUP

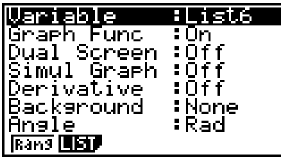


```
Variable      :Range
Graph Func    :On
Dual Screen   :Off
Simul Graph   :Off
Derivative    :Off
Background    :None
Angle         :Rad
```

F1 F2

- If the highlighting is not located at the Variable item, use ▲ and ▼ to move it there.

F2(LIST) F6(List6)



```
Variable      :List6
Graph Func    :On
Dual Screen   :Off
Simul Graph   :Off
Derivative    :Off
Background    :None
Angle         :Rad
```

After specifying the list you want to use, press EXIT to return to the previous screen.

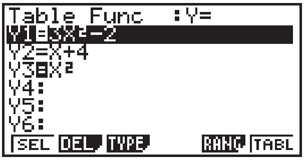
- Note that the RANG item for function key F5 of the TABLE Menu function list does not appear when a list name is specified for the Variable item of the set up screen.

■ 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 are highlighted on the screen. To deselect a function, move the cursor to it and press F1 (SEL) again.

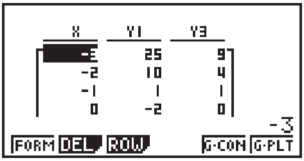


```
Table Func  :Y=
Y1=3X²-2
Y2=X+4
Y3=X²
Y4:
Y5:
Y6:
```

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.

F6 (TABL)



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 ◀, ▶, ▲, and ▼ 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 the selected cell (in columns Y1, Y2, etc.)
- To change x variable values by replacing values in column X.

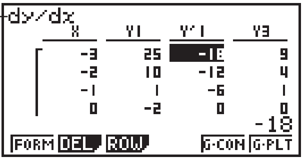
Press F1 (FORM) to return to the TABLE Mode function list.

P.6

•To generate a differential numeric table

In the set up screen, change the setting of the Derivative item to On. Once you do this, the derivative is shown on the display whenever you generate a numeric table.

Locating the cursor at a differential coefficient displays the derived function.



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.

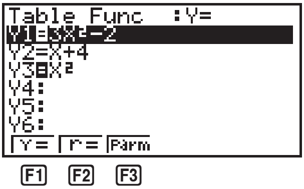
Specifying the function type

You can specify a function as being one of three types.

- Rectangular coordinate
- Polar coordinate
- Parametric

To display the menu of function types, press F3 (TYPE) while the function list is on the screen.

F3(TYPE)



```
Table Func   :Y=
Y1=3X²-2
Y2=X+4
Y3■X²
Y4:
Y5:
Y6:
```

Press the function key (F1, F2, F3) that corresponds to the function type you want to specify.

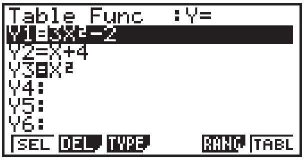
- When you generate a numeric table, a table is generated only for the function type you specify here.

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
Y2=X+4
Y3=X²
Y4:
Y5:
Y6:
```

Use ◀ and ▶ to move the cursor to the location of the change.

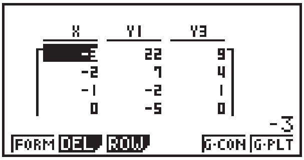
▶ ▶ ▶ ▶ ▶ 5

```
Table Func   :Y=
Y1=3X²−5_
Y2=X+4
Y3=X²
Y4:
Y5:
Y6:
    To Store :[EXE]
```

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

Use ▲ and ▼ to move the highlighting to the function you want to delete and then press F2 (DEL).

F2(DEL)

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.

F6(TABL)

F1 F2 F3 F5 F6

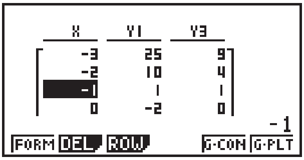
P.146

F1 (FORM) .... Display function list
F2 (DEL) .... Delete table
F3 (ROW) ...... Display menu of row operations
F5 (G•CON) .. Draw connected type graph
F6 (G•PLT) .... Draw plot type graph

•To change variable values in a table

Example **To change the value in Column x, Row 3 of the table generated on page 239 from – 1 to – 2.5**

▼▼



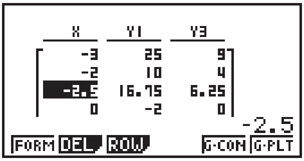
X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-1

(–) 2 • 5

-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 Ma 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.

F3(ROW)

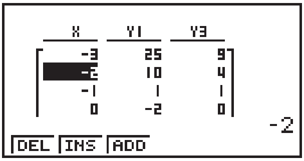
F1 F2 F3

F1 (DEL) .... Delete row
F2 (INS) .... Insert row
F3 (ADD) .... Add row

•To delete a row

Example **To delete Row 2 of the table generated on page 239**

F3(ROW) ▽

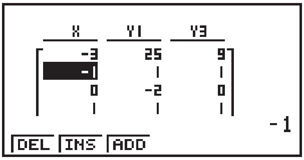


X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-2

F1

F1(DEL)



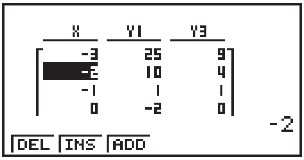
X	Y1	Y3
-3	25	9
-1	1	1
0	-2	0
1	1	1

-1

•To insert a row

Example **To insert a new row between Rows 1 and 2 in the table generated on page 239**

F3 (ROW) ▼

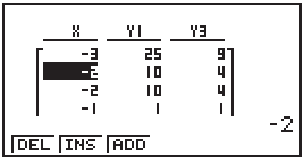


X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-2

F2

F2 (INS)



X	Y1	Y3
-3	25	9
-2	10	4
-2	10	4
-1	1	1

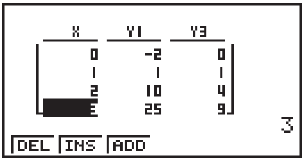
-2

•To add a row

Example **To add a new row below Row 7 in the table generated on page 239**

F3 (ROW)

▼ ▼ ▼ ▼ ▼ ▼

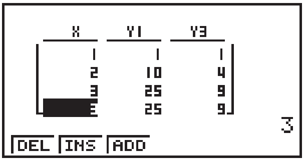


X	Y1	Y3
0	-2	0
1	1	1
2	10	4
3	25	9

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).

F2 (DEL)

F1 F6

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

Graphing a Function

•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

P.238

To specify the draw/non-draw status, use same procedure as that for specifying table generation/non-generation status.

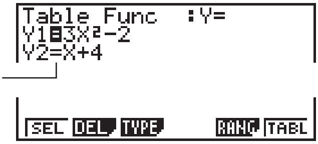
•To graph only a selected function

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**

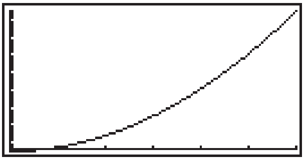
▽ F1 (SEL)
(Specifies graph non-draw.)



```
Table Func   :Y=
Y1⊟3X²-2
Y2=X+4
```

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.**

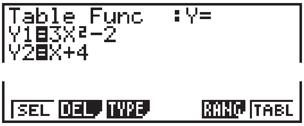


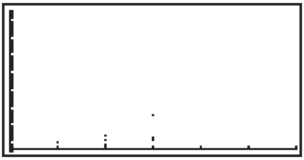
Table Func :Y=
Y1■3X²−2
Y2■X+4

F6

F6(TABL)

F6

F6(G•PLT)
(Specifies plot type graph.)



P.146

- 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 Graph Functions".

P.8

•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 are Y1, displaying both the graph and its table**

Use the same View Window parameters as in the example on page 245.

SHIFT SETUP

▼ ▼ F1 (T+G)

(Specifies T+G for Dual Screen.)

Dual Screen :T+G

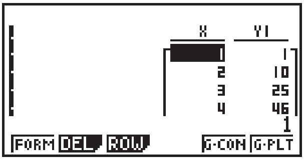
F1

EXIT

F6

F6 (TABL)

(Shows the table.)



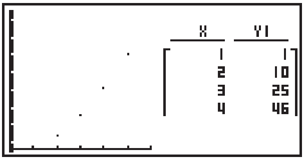
X	Y1
1	1
2	10
3	25
4	46

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).

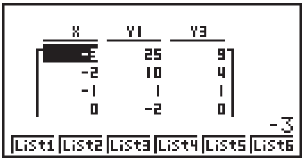
15-5 Copying a Table Column to a List

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)



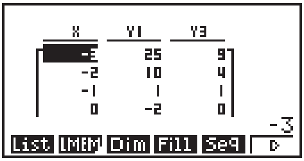
X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

- You can select any row of the column you want to copy.

Press the function key (F1 to F6) 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.

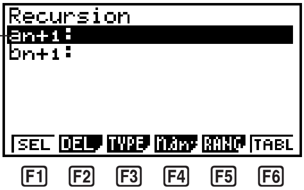
- General term of sequence $\{a_n\}$, made up of a_n and n
- Formulas for linear recursion between two terms, made up of a_{n+1}, a_n, and n
- Formulas for linear recursion between three terms, made up of a_{n+2}, a_{n+1}, a_n, and n

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.

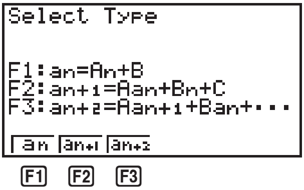
F1 (SEL) .... Menu for control of table generation
F2 (DEL) .... Recursion formula delete
F3 (TYPE) ..... Recursion formula type specification
F4 (n, a_n...) .... Menu for input of variable n and general terms a_n and b_n
F5 (RANG) .... Screen for setting of table range
F6 (TABL) ...... Recursion formula 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).

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}.

F1 (a_n) .... General term of sequence {a_n}
F2 (a_{n+1}) .... Linear recursion between two terms
F3 (a_{n+2}) .... Linear recursion between three terms

2. Press the function key for the recursion formula type you want to set.

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 and then press F5 (RANG) to display the table range setting screen.

EXE F5 (RANG)

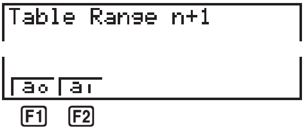


Table Range n+1

F1 (a_0)	Value for a_0 (b_0)
F2 (a_1)	Value for a_1 (b_1)

P.258

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.

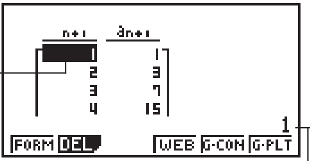
3. Specify the range of the table.

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	a_{n+1}
1	1
2	3
3	7
4	15

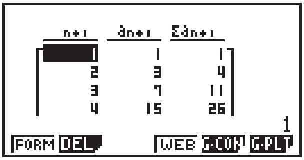
1

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.
- You can also display the sums of the terms (Σa_n or Σb_n) by turning on Σ Display.

P.9



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...)
F3(a_{n+1}) + F2(a_n)


Recursion
an+2=an+1+an_

2. Press EXE and then press F5 (RANG) to display the table range setting screen.

EXE F5(RANG)

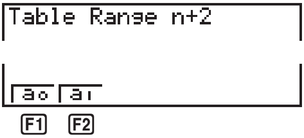


Table Range n+2

F1 (a_0) .... Value for a_0 (b_0) and a_1 (b_1)
F2 (a_1) .... Value for a_1 (b_1) and a_2 (b_2)

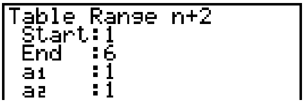
The table range settings specify the conditions that control the value of variable n in the recursion formula, and the initial term of the numeric value table.

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.

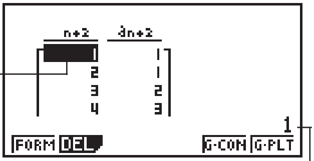
F2 (a_1)
1 EXE 6 EXE 1 EXE 1 EXE



```
Table Range n+2
 Start:1
 End  :6
 a1   :1
 a2   :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	an+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.

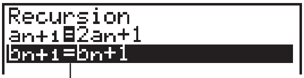
- Changing the angle unit setting while a table generated from a trigonometric expression is on the display does not cause the displayed values to change. To cause the values in the table to be updated using the new setting, display the table, press F1 (FORM), change the angle unit setting, and then 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)

(Specifies non-generation status.)

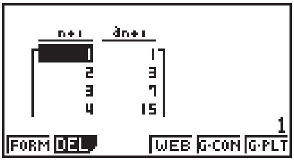


Recursion
an+1=2an+1
bn+1=bn+1

Unhighlights this formula

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).

•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.

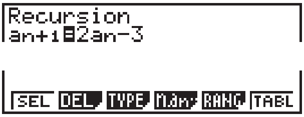
Example **To change $a_{n+1} = 2a_n+1$ to $a_{n+1} = 2a_n–3$**

▶

(Displays the cursor.)

▶ ▶ − 3 EXE

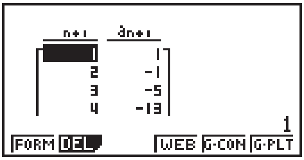
(Changes the formula contents.)



Recursion
an+1=2an−3

F6

F6 (TABL)



n+1	an+1
1	1
2	-1
3	-5
4	-13

1

•To delete a recursion formula

1. Display the Recursion Menu and then use ▲ and ▼ to highlight the formula you want to delete.

2. Press F2 (DEL).

3. 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/dievergence (WEB)

You can access these options from the function menu that appears at the bottom of the screen whenever a table is displayed.

F1 (FORM) .... Returns to Recursion Menu.
F2 (DEL) .... Table delete
F4 (WEB) ...... Draws convergence/divergence graph (WEB graph). P.259
F5 (G•CON) .. Draws connected type recursion graph. P.146
F6 (G•PLT) .... Draws plot type recursion graph. P.146

- The WEB item (F4) 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.

- Draw/non-draw status of for the recursion formula
- The type of data to be plotted

To specify the draw/non-draw status, display the Recursion Menu and then press F1 (SEL).

•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
- Overly the graphs for both recursion formulas

P.254

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.

F1 (a_n) .... a_n on the vertical axis, n on the horizontal axis

F6 (Σa_n) .... Σa_n on the vertical axis, n on the 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.**

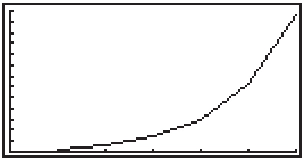
Set the following parameters in the View Window.

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.

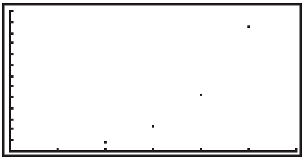
F6(TABL) F6(G•PLT)

(Selects plot type.)

SELECT 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.**

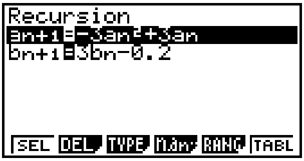
Use the following table range.

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
$a_{n+1}=-3a_n^2+3a_n$
$b_{n+1}=3b_n-0.2$

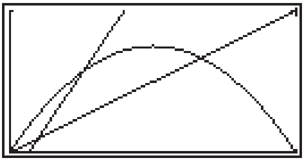
F6

1. Press F6 (TABL) to generate a table.

   F6(TABL)

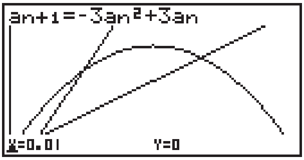
2. Press F4 (WEB) to draw the graph.

   F4(WEB)



3. Press EXE, and the pointer appears at the pointer start point (a_nStr = 0.01).

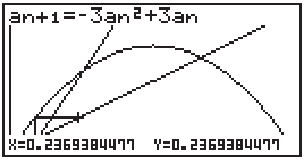
   EXE


$a_{n+1}=-3a_n^2+3a_n$
X=0.01 Y=0

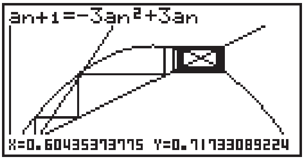
- The Y value for the pointer start point is always 0.

4. Each press of EXE draws web-like lines on the display.

EXE


$a_{n+1}=-3a_n^2+3a_n$
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.

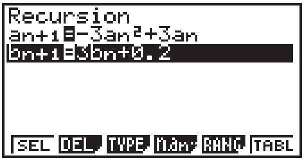
Example 2 **To determine whether or not the recursion formula $b_{n+1} = 3b_n + 0.2$ is convergent or divergent.**

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

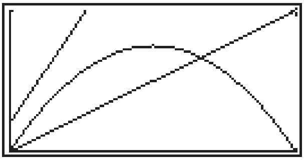
an+1=-3an²+3an

bn+1=3bn+0.2

F6

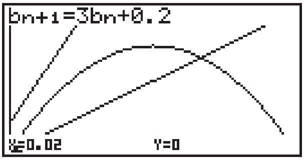
1. Press F6 (TABL) F4 (WEB) to draw the graph.

F6(TABL)
F4(WEB)



2. Press EXE and then either ⏶ or ⏷ to make the pointer appear at the pointer start point (b_nStr = 0.02).

EXE ⏷ (or ⏶)



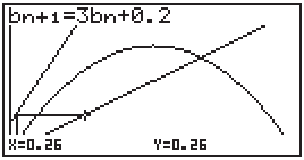
bn+1=3bn+0.2

X=0.02 Y=0

- The Y value for the pointer start point is always 0.

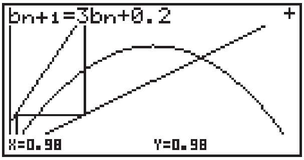
3. Each press of EXE draws web-like lines on the display.

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.

P.8
P.258

•To draw 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**

SHIFT SET UP

▼ ▼ ▼ F1(T+G)

(Specifies T+G for Dual Screen.)


Dual Screen :T+G

EXIT F6(TABL)

(Draws the graph and shows the table.)

F6(G•PLT)

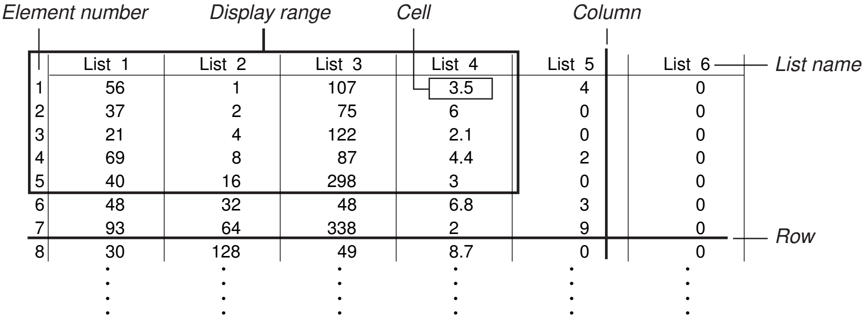
(Draws plot type graph.)

- 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

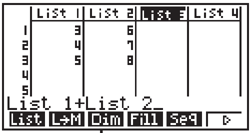
Operation

Graph

List operation

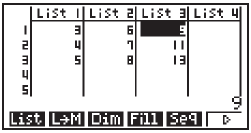
Example:
List 1 + List 2
{1, 2, 3} + {4, 5, 6}
List 1 + 3

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

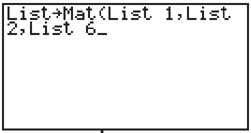
Y1=List 1X

From a graph to a list

Table data generated by GRAPH TO TABLE to a list

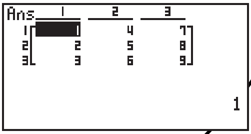
LIST

Memory transfer



```
List→Mat(List 1,List
2,List 6_
```

EXE



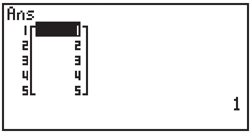
```
Ans  1   2   3
 1 [ 1   4   7 ]
 2 [ 2   5   8 ]
 3 [ 3   6   9 ]
                1
```

Generating a table by defining a list as the variable.

Memory transfer

```
Mat→List(Mat A,1
```

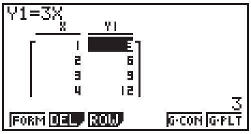
EXE



```
Ans
 1 [ 1 ]
 2 [ 2 ]
 3 [ 3 ]
 4 [ 4 ]
 5 [ 5 ]
          1
```

Example: To send column 1 of Mat A to a list

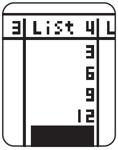
Copying the column of a specific table to a specific list.



```
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

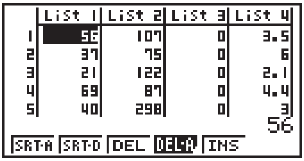
17-1 List Operations

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 ◀ and ▶ to move between lists, and ▲ and ▼ to move between cells inside of a list.

The screen automatically scrolls when the cursor is located at the edge of the screen.

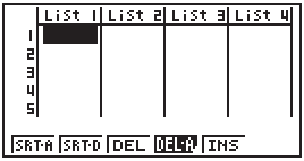


	List 1	List 2	List 3	List 4
1	56	107	0	3.5
2	37	75	0	6
3	21	122	0	2.1
4	69	87	0	4.4
5	40	298	0	3

56

- ▼ does not move the cursor to a cell that does not contain a value.

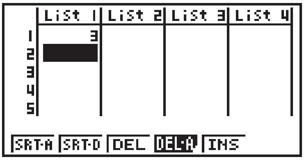
For our example, we will start by locating the cursor in Cell 1 of List 1.



	List 1	List 2	List 3	List 4
1				
2				
3				
4				
5				

1. Input a value and press EXE to store it in the list.

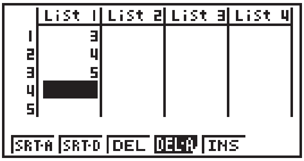
3 EXE



	List 1	List 2	List 3	List 4
1	3			
2				
3				
4				
5				

2. The cursor automatically moves down to the next cell for input.
   - Note that you can also use the result of an expression as list input. The next operation shows how to input the value 4 in the second row and then input the result of 2 + 3 in the next row.

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 ▲ to move the cursor to the list name.

▲▲▲▲

	List 1	List 2	List 3	List 4
1	3			

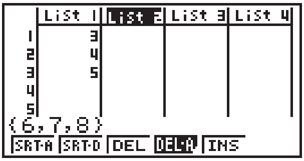
2. Use ◀ or ▶ to move the cursor to another list.

▶

	List 1	List 2	List 3	List 4
1	3			

3. 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 }

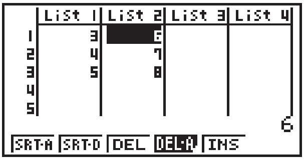


	List 1	List 2	List 3	List 4
1	3			
2	4			
3	5			
4				
5				

{6,7,8}

4. Press EXE to store all of the values in your list.

EXE



	List 1	List 2	List 3	List 4
1	3	6		
2	4	7		
3	5	8		
4				
5				

6

- 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.

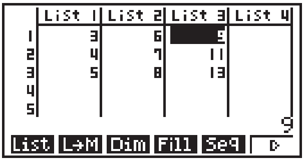
1. Use ◀, ▶, ▲, and ▼ to move the cursor to the name of the list where you want the calculation results to be input.

▲▶

	List 1	List 2	List 3	List 4
1	3	6		

2. Press OPTN and input the expression.

OPTN F1(LIST) F1(List) 1 +
F1(List) 2 EXE



	List 1	List 2	List 3	List 4
1	3	6	9	
2	4	7	11	
3	5	8	13	
4				
5				

9

EXIT EXIT

17-2 Editing and Rearranging Lists

Editing List Values

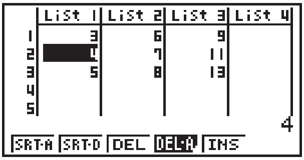
•To change a cell value

Use ◀ or ▶ to move the cursor 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 ◀, ▶, ▲, or ▼ to move the cursor to the cell you want to delete.

◀◀▼



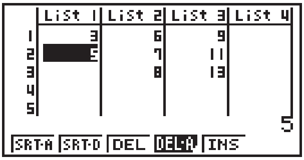
	List 1	List 2	List 3	List 4
1	3	6	9	
2	4	7	11	
3	5	8	13	
4				
5				

4

F3

2. Press F3 (DEL) to delete the selected cell and cause everything below it to be shifted up.

F3(DEL)



	List 1	List 2	List 3	List 4
1	3	6	9	
2	5	7	11	
3		8	13	
4				
5				

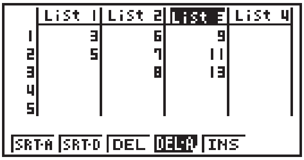
5

- 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

1. Use ◀, ▶, ▲ or ▼ to move the cursor to the name of the list whose cells you want to delete.

▲▲▶▶



	List 1	List 2	List 3	List 4
1	3	6	9	
2	5	7	11	
3		8	13	
4				
5				

F4

2. Press F4 (DEL-A). The function menu changes to confirm whether you really want to delete all the cells in the list.

F4(DEL-A)

3. Press F1 (YES) to delete all the cells in the selected list or F6 (NO) to abort the delete operation without deleting anything.

F1(YES)

•To insert a new cell

Use ◀, ▶, ▲, or ▼ to move the cursor to the location where you want to insert the new cell. In this example, we will reinsert a cell containing the value 4, which we deleted above.

1. Press F5 (INS) to insert a new cell, which contains a value of 0, causing everything below it to be shifted down.

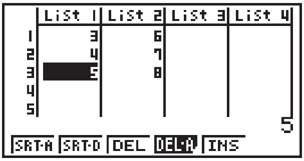
◀ ◀ ▼ F5(INS)

	List 1	List 2	List 3	List 4
1	3	6		
2	0	7		
3	5	8		
4				
5				

0

2. Input the value you want into the new cell (4 in our example) and press EXE.

4 EXE



	List 1	List 2	List 3	List 4
1	3	6		
2	4	7		
3	5	8		
4				
5				

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

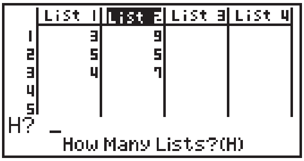
You can sort lists into either ascending order or descending order. The current cursor location does not matter in the following procedures.

•To sort a single list

Ascending order

1. While the lists are on the screen, press F1 (SRT-A).

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.

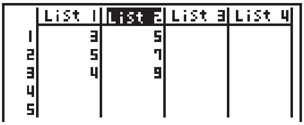
1 EXE

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				

The values in List 2 are sorted into ascending order.

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).

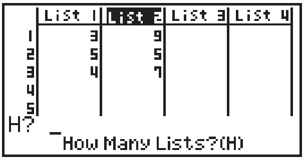
•To sort multiple lists

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).

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)

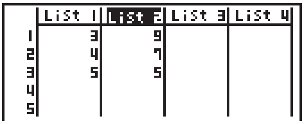
3. In response to the "Select Base List (B)" prompt, input the number of the list you want to sort into ascending order. Here we will specify List 1.

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				

The values in List 1 are sorted into ascending order, and the cells of List 2 are also rearranged to keep the same relationship with the List 1 cells.

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. There is also a collection of powerful list data manipulation functions that let you do the following.

- Count the number values (Dim)
- Replace all cell values with the same value (Fill)
- Generate a sequence of numbers (Seq)
- Find the minimum value in a list (Min)
- Find the maximum value in a list (Max)
- Find which of two lists contains the smallest value (Min)
- Find which of two lists contains the greatest value (Max)
- Calculate the mean of list values (Mean)
- Calculate the mean of values of specified frequency (Mean)
- Calculate the median of values in a list (Med)
- Calculate the median of values of specified frequency (Med)
- Calculate the sum of values in a list (Sum)
- Calculate the sum of products (Prod)
- Calculate cumulative frequency of each value (Cuml)
- Calculate the percentage represented by each value (%)
- Transfer list contents to Matrix Answer Memory (List → Mat)

You 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). This menu has three pages and you can advance to the next page by pressing F6 (▷).

Note that all closing parentheses at the end of the following operations can be omitted.

•To count the number of values (Dim)

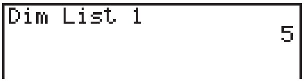
OPTN F1(LIST) F3(Dim) F1(List) <list number 1-6> EXE

- 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



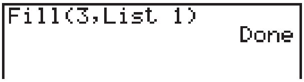
```
Dim List 1
                    5
```

•To replace all cell values with the same value (Fill)

OPTN F1 (LIST) F4 (Fill) <value> , F1 (List) <list number 1-6>) EXE

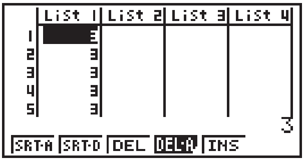
Example **To replace all values in List 1 (36, 16, 58, 46, 56) with 3**

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
                             3
SRT-A SRT-D DEL DEL-A INS
```

•To generate a sequence of numbers (Seq)

OPTN F1 (LIST) F5 (Seq) <expression> , <variable name> , <start value> , <end value> , <pitch>) EXE

- The result of this operation is also stored in ListAns Memory.

Example **To input the number sequence 1², 6², 11² into a list**

Use the following settings.

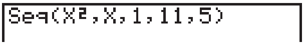
Variable: x

Starting value: 1

Ending value: 11

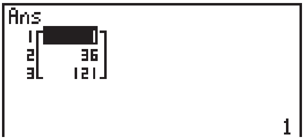
Pitch: 5

AC OPTN F1 (LIST) F5 (Seq) X,θ,T
x² , X,θ,T , 1 , 1 1 , 5)



```
Seq(X²,X,1,11,5)
```

EXE



```
Ans
 1[   1]
 2[  36]
 3[ 121]
                  1
```

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).

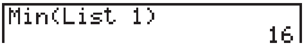
The resulting sequence is input into ListAns Memory.

•To find the minimum value in a 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 (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 (Min)

OPTN F1 (LIST) F6 (▷) F1 (Min) F6 (▷) F6 (▷) F1 (List) <list number 1-6> , F1 (List) <list number 1-6>) EXE

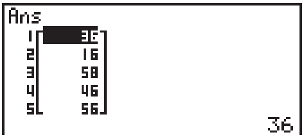
- The two lists must contain the same number of values. If they don't, an error (Dim ERROR) occurs.
- The result of this operation is also stored in ListAns Memory.

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)

```
Min(List 1,List 2)
```

EXE



```
Ans
 1[ 36]
 2  16
 3  58
 4  46
 5L 56]
                 36
```

•To find which of two lists contains the greatest value (Max)

Use the same procedure as that for the smallest value, except press F2 (Max) in place of F1 (Min).

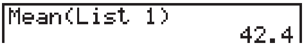
- The two lists must contain the same number of values. If they don't, an error (Dim ERROR) occurs.

•To calculate the mean of list values (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 (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 (Dim 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 (Median)

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 (Median)

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 (Dim 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 (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

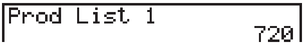

```
Sum List 1
                  212
```

•To calculate the sum of products (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
```

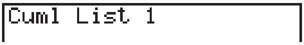
•To calculate the cumulative frequency of each value (Cuml)

OPTN F1 (LIST) F6 (▷) F6 (▷) F3 (Cuml) F6 (▷) F1 (List) <list number 1-6> EXE

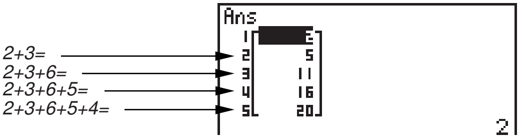
Example **To calculate the cumulative frequency of each value in List 1 (2, 3, 6, 5, 4)**

The result is displayed in ListAns Memory.

AC OPTN F1(LIST) F6(▷) F6(▷)
F3(Cuml) F6(▷) F1(List) 1


```
Cuml List 1
```

EXE



```
Ans
 1[   2]
 2    5
 3   11
 4   16
 5   20
                    2
```

•To calculate the percentage represented by each value (%)

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.

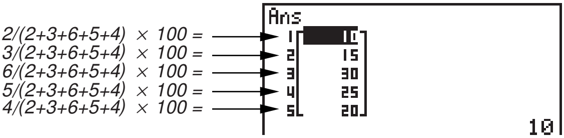
Example **To calculate the percentage represented by each value in List 1 (2, 3, 6, 5, 4)**

The result is displayed in ListAns Memory.

AC OPTN F1 (LIST) F6 (▷) F6 (▷)
F4 (%) F6 (▷) F1 (List) 1

```
Percent List 1
```

EXE



2/(2+3+6+5+4) × 100 =
3/(2+3+6+5+4) × 100 =
6/(2+3+6+5+4) × 100 =
5/(2+3+6+5+4) × 100 =
4/(2+3+6+5+4) × 100 =

```
Ans
 1[ 10]
 2  15
 3  30
 4  25
 5[ 20]
        10
```

•To transfer list contents to Matrix Answer Memory (List → Mat)

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.

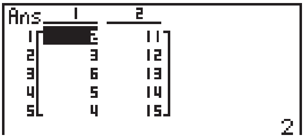
  , <list number 1-6>

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)

```
List→Mat(List 1,List
2)
```

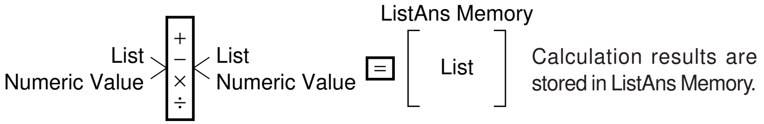
EXE



```
Ans    1     2
 1[    2    11]
 2     3    12
 3     6    13
 4     5    14
 5[    4    15]
              2
```

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, a Dim ERROR occurs if the two lists do not have the same number of values (which means they have different "dimensions").
- An Ma 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.

OPTN

F1

2. Press F1 (LIST) to display the List Data Manipulation Menu.

F1(LIST)

F1

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 { 56 , 82 , 64 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

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.

P.126

There are certain limitations on using lists with graphing functions.

P.248

Inputting Scientific Calculations into a List

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 $\begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$ and List 2 $\begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix}$ to perform List $1^{\text{List 2}}$**

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

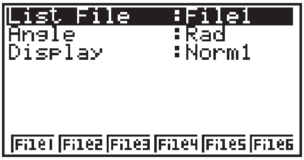
You can store up to six lists (List 1 to List 6) in each file (File 1 to File 6). A simple operation lets you switch between list files.

•To switch between list files

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

Press SHIFT SET UP to display the LIST Mode set up screen.

SHIFT SET UP

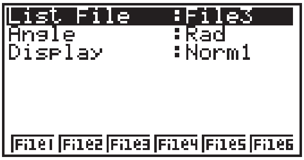

List File :File1
Angle :Rad
Display :Norm1

F1 F2 F3 F4 F5 F6

Press the function key (F1 to F6) to select the file you want.

Example **To select File 3**

F3(File3)


List File :File3
Angle :Rad
Display :Norm1

EXIT

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, and how to calculate the mean, maximum and other statistical values. It also tells you how to perform regression calculations.

Important!

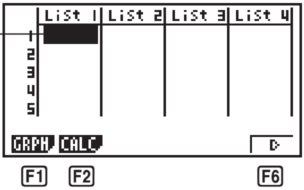
- This chapter contains a number of graph screen shots. In each case, new data values were input in order to highlight the particular characteristics of the graph being drawn. Note that when you try to draw a similar graph, the unit uses data values that you have input using the List function. Because 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.285 F1 (GRPH) .... Graph menu

P.305 F2 (CALC) ..... Statistical calculation menu

F6 (▷) .... Next menu

F6(▷)

P.270 F1 (SRT•A) .... Ascending sort

P.270 F2 (SRT•D) ... Descending sort

P.268 F3 (DEL) .... Single data item delete

P.269 F4 (DEL•A) .... Delete all data

P.269 F5 (INS) .... Insert data item

F6 (▷) .... Previous menu

P.263
- 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.

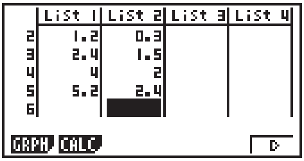
Example **To input the following two data groups and perform statistical calculations**

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 Data

Example **To specify Graph 1 as non-draw (Off) and Graph 3 as draw (On) and use Graph 3 to plot the data you input into statistical data List 1 and List 2 above**

While the statistical data list is on the display, press F1 (GRPH) to display the graph menu.

F1(GRPH)

F1 (GPH1) ..... Graph 1 draw
F2 (GPH2) ..... Graph 2 draw
F3 (GPH3) ..... Graph 3 draw
F4 (SEL)........ Graph (GPH1, GPH2, GPH3) selection
F6 (SET) .... Graph settings (graph type, list assignments)

P.287
P.288

- 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.

P.287

- 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.

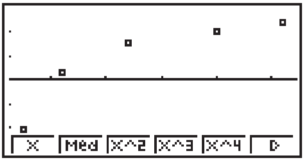
Plotting a Scatter Diagram

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 relationships often become clear however, when we plot the data on a graph, using one set as x-values and the other set as y-values.

•To plot a scatter diagram

Example **To plot the data we input in statistical data List 1 and List 2**

F1(GPH1)



- The default setting automatically uses List 1 data as x-axis values and List 2 data as y-axis values. Each set of x/y data is a point on the scatter diagram.
- To return to the statistical data list, press EXIT or SHIFT QUIT.

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).

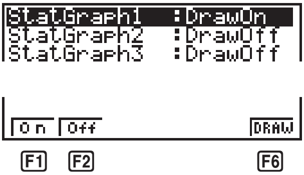
1. Graph draw/non-draw status (SELECT)

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. While the graph menu is on the display, press F4 (SEL) to display the graph On/Off screen.

F1(GRPH)
F4(SEL)


StatGraph1 :DrawOn
StatGraph2 :DrawOff
StatGraph3 :DrawOff

F1 (On) .... Graph On (graph draw)
F2 (Off) .... Graph Off (graph non-draw)
F6 (DRAW).... Draw all On graphs

- 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.

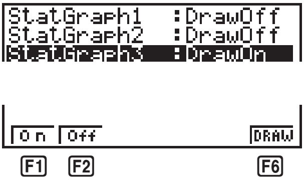
2. Use ▲ and ▼ to move the highlighting to the graph whose draw (On)/non-draw (Off) status you want to change and press F1 (On) or F2 (Off).

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

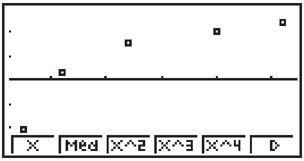
•To draw a graph

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

F1(GRPH) F4(SEL)
F2(Off)
▼ ▼ F1(On)


StatGraph1 :DrawOff
StatGraph2 :DrawOff
StatGraph3 :DrawOn

F6(DRAW)



2. General graph settings (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 is statistical data 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.

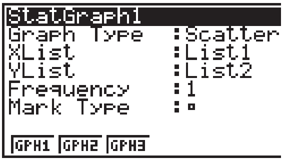
• Mark Type

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

•To display the general graph settings (SET) screen

While the graph menu is on the display, press F6 (SET) to display the general graph settings screen.

F1(GRPH)
F6(SET)



StatGraph1
Graph Type :Scatter
XList :List1
YList :List2
Frequency :1
Mark Type :▫

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

•To select the StatGraph area

1. While the general graph settings screen is on the display, use ▲ and ▼ to move the highlighting to the StatGraph item.

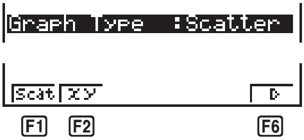
StatGraph1

2. Use the function key menu to select the StatGraph area you want to select.

F1 (GPH1) ..... Graph 1
F2 (GPH2) ..... Graph 2
F3 (GPH3) ..... Graph 3

•To select the graph type (Graph Type)

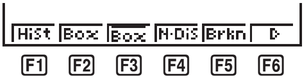
1. While the general graph settings screen is on the display, use ▲ and ▼ to move the highlighting to the Graph Type item.


Graph Type :Scatter

2. Use the function key menu to select the graph type you want to select.

F1 (Scat) .... Scatter diagram
F2 (*xy*) .... *xy* line graph
F6 (▷) .... Next menu

F6(▷)



F1 (Hist) .... Histogram (bar graph)
F2 (Box) .... Med-box graph
F3 ($\overline{\text{Box}}$) .... Mean-box graph
F4 (N•Dis) ..... Normal distribution curve
F5 (Brkn) .... Line graph
F6 (▷) .... Next menu

F6(▷)

F1 (X) .... Linear regression graph
F2 (Med) .... Med-Med graph
F3 (X^2) .... Quadratic regression graph
F4 (X^3) .... Cubic regression graph
F5 (X^4) .... Quartic regression graph
F6 (▷) .... Next menu

F6(▷)

F1 (Log) .... Logarithmic regression graph
F2 (Exp) .... Exponential regression graph
F3 (Pwr) .... Power regression graph
F6 (▷) .... Previous menu

•To select the *x*-axis data list (XList)

1. While the graph settings screen is on the display, use ▲ and ▼ to move the highlighting to the XList item.

XList :List1

2. Use the function key menu to select the name of the statistical data list whose values you want on the *x*-axis of the graph.

F1 (List1) .... List 1
F2 (List2) .... List 2
F3 (List3) .... List 3
F4 (List4) .... List 4
F5 (List5) .... List 5
F6 (List6) .... List 6

•To select the *y*-axis data list (YList)

1. While the graph settings screen is on the display, use ▲ and ▼ to move the highlighting to the YList item.

YList :List1

2. Use the function key menu to select the name of the statistical data list whose values you want on the *y*-axis of the graph.

F1 (List1) .... List 1
F2 (List2) .... List 2

F3 (List3) .... List 3

F4 (List4) .... List 4

F5 (List5) .... List 5

F6 (List6) .... List 6

•To select the frequency data list (Frequency)

1. While the general graph settings screen is on the display, use ⏶ and ⏷ to move the highlighting to the Frequency item.

Frequency :1

2. Use the function key menu to select the frequency setting you want.

F1 (1) .... Plot all data (1-to-1)

F2 (List1) .... List 1 data is frequency data.

F3 (List2) .... List 2 data is frequency data.

F4 (List3) .... List 3 data is frequency data.

F5 (List4) .... List 4 data is frequency data.

F6 (▷) .... Next menu

F6(▷)

F1 (List5) .... List 5 data is frequency data.

F2 (List6) .... List 6 data is frequency data.

F6 (▷) .... Previous menu

•To select the plot mark type (Mark Type)

1. While the general graph settings screen is on the display, use ⏶ and ⏷ to move the highlighting to the Mark Type item.

Mark Type :▫

2. Use the function key menu to select the plot mark you want to select.

F1 (□) .... Plot using □

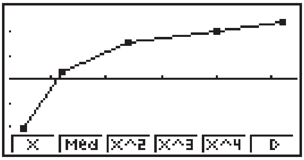
F2 (X) .... Plot using X

F3 (•) .... Plot using •

P.289
(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.

Selecting the Regression Type

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

F1 F2 F3 F4 F5 F6

F1 (X) .... Linear regression graph
F2 (Med) .... Med-Med graph
F3 (X^2) .... Quadratic regression graph
F4 (X^3) .... Cubic regression graph
F5 (X^4) .... Quartic regression graph
F6 (▷) .... Next menu

F6(▷)

F1 F2 F3 F4 F6

F1 (Log) .... Logarithmic regression graph
F2 (Exp) .... Exponential regression graph
F3 (Pwr) .... Power regression graph
F4 (2VAR) ..... Paired-variable statistical results
F6 (▷) .... Previous menu

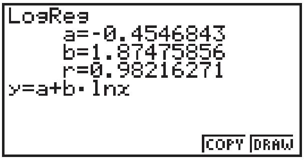
■ Displaying Statistical Calculation Results

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
y=a+b·lnx
```

■ Graphing Statistical Calculation Results

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

P.302

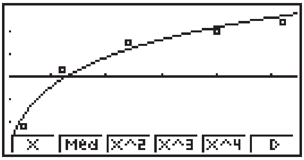
F5 (COPY) .... Stores the displayed regression formula as a graph function

F6 (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).

F6(DRAW)



P.292

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 five types of graphs are available for single-variable statistics.

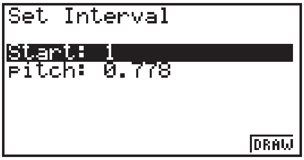
■ Drawing a Histogram (Bar Graph)

P.285

P.289
(Graph Type)
(Hist)

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).

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

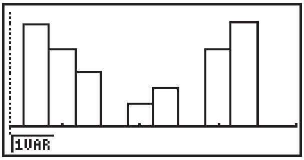


Set Interval

Start: 1
pitch: 0.778

F6

⇒
F6 (DRAW)



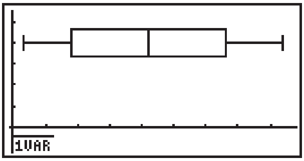
The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and pitch values.

■ Med-box Graph (Med-Box)

P.289
(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.



■ Mean-box Graph

P.289
(Graph Type)
($\overline{\text{Box}}$)

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.289
(Graph Type)
(N•Dis)

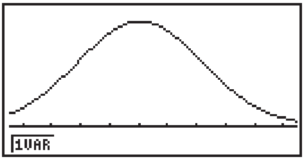
Normal Distribution Curve

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.

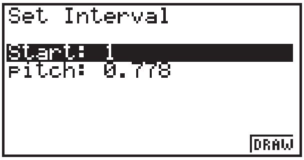


P.289
(Graph Type)
(Brkn)

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.

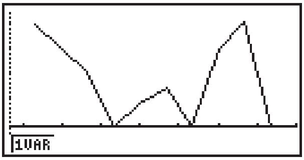
Calling up the graph menu from the statistical data list, pressing F6 (SET), changing the settings to drawing of a line graph, and then drawing a graph creates a box graph.


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.

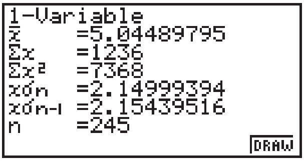
Displaying Single-Variable Statistical Results

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.

F1 (1VAR) ..... Single-variable calculation result menu

Pressing F1 (1VAR) displays the following screen.

F1(1VAR)



```
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 six regression functions.

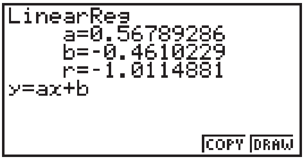
P.289

■ Linear Regression Graph

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

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

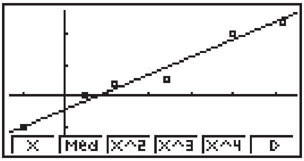
(Graph Type)	SHIFT QUIT F1(GRPH) F6(SET) ▼
(Scatter)	F1(Scat)
(GPH1)	SHIFT QUIT F1(GRPH) F1(GPH1)
(X)	F1(X)



```
LinearReg
     a=0.56789286
     b=-0.4610229
     r=-1.0114881
y=ax+b
```

F6

F6(DRAW)



The following are the meanings of the above parameters.

a ...... Regression coefficient (slope)

b ...... Regression constant term (intercept)

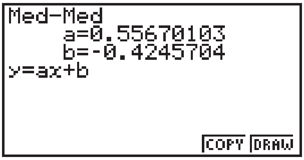
r ...... Correlation coefficient

P.289

■ Med-Med Graph

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

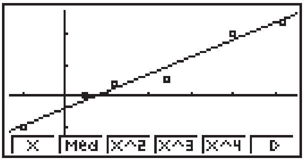
F2(Med)



```
Med-Med
     a=0.55670103
     b=-0.4245704
y=ax+b
```

F6

F6(DRAW)



The following are the meanings of the above parameters.

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

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

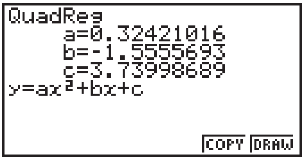
P.289

■ 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

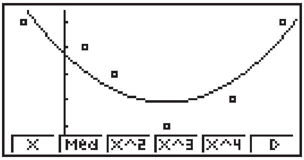
F3(X^2)



```
QuadReg
    a=0.32421016
    b=-1.5555693
    c=3.73998689
y=ax²+bx+c
```

F6

F6(DRAW)



The following are the meanings of the above parameters.

Quadratic regression

a ...... Quadratic regression coefficient

b ...... Linear regression coefficient

c ...... Regression constant term (intercept)

Cubic regression

a ...... Cubic regression coefficient

b ...... Quadratic regression coefficient

c ...... Linear regression coefficient

d ...... Regression constant term (intercept)

Quartic regression

a ...... Quartic regression coefficient

b ...... Cubic regression coefficient

c ...... Quadratic regression coefficient

d ...... Linear regression coefficient

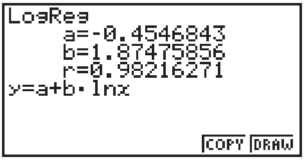
e ...... Regression constant term (intercept)

P.290

■ Logarithmic Regression Graph

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

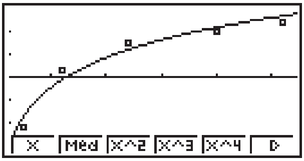
F6(▷)F1(Log)



```
LogReg
    a=-0.4546843
    b=1.87475856
    r=0.98216271
y=a+b·lnx
```

F6

F6(DRAW)



The following are the meanings of the above parameters.

a ...... Regression constant term (intercept)

b ...... Regression coefficient (slope)

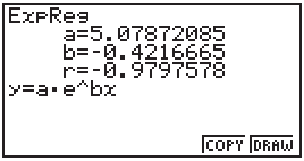
r ...... Correlation coefficient

P.290

■ 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 log$y$ = log$a$ + bx. Next, if we say Y = log$y$, and a = log$a$, the formula corresponds to linear regression formula Y = $a + bx$.

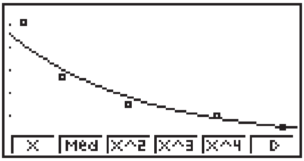
F6(▷)F2(Exp)



```
ExpReg
    a=5.07872085
    b=-0.4216665
    r=-0.9797578
y=a·e^bx
```

F6

F6(DRAW)



The following are the meanings of the above parameters.

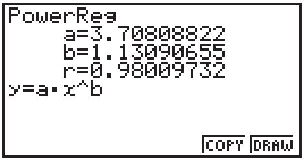
a ...... Regression coefficient
b ...... Regression constant term
r ...... Correlation coefficient

P.290

■ 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 log$y$ = log$a$ + b × log$x$. Next, if we say X = log x, Y = log$y$, and a = log$a$, the formula corresponds to linear regression formula Y = a + bX.

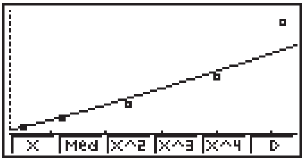
F6(▷)F3(Pwr)



```
PowerReg
    a=3.70808822
    b=1.13090655
    r=0.98009732
y=a·x^b
```

F6

F6(DRAW)



The following are the meanings of the above parameters.

a ...... Regression coefficient
b ...... Regression power
r ...... Correlation coefficient

P.290

■ Displaying Paired-Variable Statistical Results

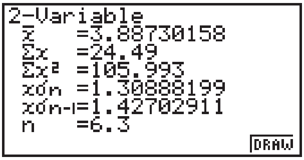
Paired-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the menu at the bottom of the screen appears as below.

F4

F4(2VAR) ...... Paired-variable calculation result menu

Pressing F4 (2VAR) displays the following screen.

F4(2VAR)



```
2-Variable
 x̄   =3.88730158
 Σx  =24.49
 Σx² =105.993
 xσn =1.30888199
 xσn-1=1.42702911
 n   =6.3
```

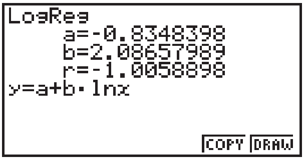
- Use ⏷ to scroll the list so you can view the items that run off the bottom of the screen. The following describes the meaning of each of the parameters.

$\overline{x}$	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
$\overline{y}$	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.



```
LogReg
    a=-0.8348398
    b=2.08657989
    r=-1.0058898
y=a+b·lnx
```

F5 F6

F5 (COPY) .... Stores the displayed regression formula to the **GRAPH Mode**

F6 (DRAW).... Graphs the displayed regression formula

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

F5(COPY)

```
Graph Func
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:
   To Store :[EXE]
```

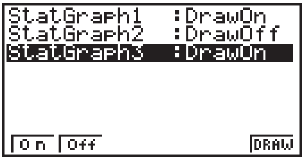
Note that you cannot edit regression formulas for graph formulas in the **GRAPH Mode**.

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

■ Multiple Graphs

P.286

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.

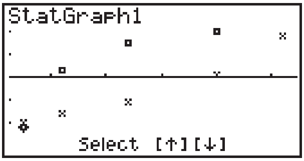


```
StatGraph1  :DrawOn
StatGraph2  :DrawOff
StatGraph3  :DrawOn
```

F6

P.289

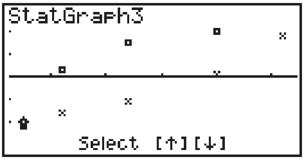
F6(DRAW)
F1(X)



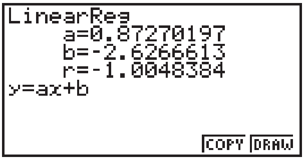
- The text at the top of the screen indicates the currently selected graph (StatGraph1 = Graph 1, StatGraph2 = Graph 2, StatGraph3 = Graph 3).

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=0.87270197
    b=-2.6266613
    r=-1.0048384
y=ax+b
```

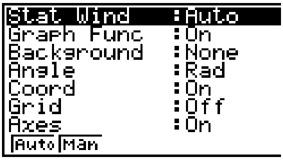
P.296
P.301

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

Manual Graphing

In all of the graphing examples up to this point, values were calculated in accordance with View Window settings and graphing was performed automatically. This automatic graphing is performed when the Stat Wind item of the View Window is set to "Auto" (auto graphing). You can also produce graphs manually, when the automatic graphing capabilities of this calculator cannot produce the results you want.

SHIFT SETUP



Stat Wind :Auto
Graph Func :On
Background :None
Angle :Rad
Coord :On
Grid :Off
Axes :On

F2

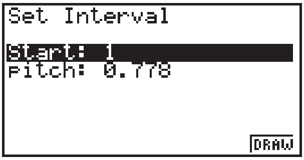
F2(Man)

Stat Wind :Manual

Performing this setting does not change View Window values, and the graph is drawn using the values currently set in the View Window.

Setting the Width of a Histogram/Line Graph

Selecting histogram or line graph as the graph type causes the following screen to appear before the graph is drawn.



Set Interval

Start: 1
pitch: 0.778

The following are the meanings of the items that appear in this screen.

Start .... Histogram/line graph start point (x-coordinate)

pitch .... Bar spacing, or point spacing (specify as scale unit)

- When "Auto" is specified for the statistical graph window setting (Stat Wind), the calculator automatically calculates standard values for Start and pitch.

Example **Start: 0, pitch: 10**

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

SHIFT SETUP F2(Man)

EXIT(Returns to previous menu.)

F1(GRPH) F1(GPH1)

0 EXE(Start value is x = 0.)

1 0 EXE(pitch = 10)

18-6 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. While the statistical data is on the display, perform the following procedure.

F2(CALC) F6(SET)

```
1Var XList  :List1
1Var Freq   :1
2Var XList  :List1
2Var YList  :List2
2Var Freq   :1
```

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.

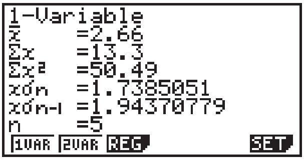
- Calculations in this section are performed based on the above specifications.

■ Single-Variable Statistical Calculations

In the previous examples from “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.

The following operation produces the same values directly from the statistical data list.

F2(CALC) F1(1VAR)



```
1-Variable
x̄      =2.66
Σx     =13.3
Σx²    =50.49
xσn    =1.7385051
xσn-1  =1.94370779
n      =5
```

Now you can press ⏶ and ⏷ to view variable characteristics.

P.296

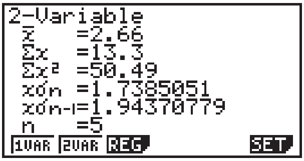
For details on the meanings of these statistical values, see "Displaying Single-Variable Statistical Results".

Paired-Variable Statistical Calculations

In the previous examples from "Linear Regression Graph" to "Power 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.

The following operation produces the same values directly from the statistical data list.

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.301

Now you can press ⏶ and ⏷ to view variable characteristics.

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

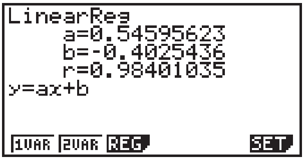
Regression Calculation

In the explanations from "Linear Regression Graph" to "Power 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.

Perform the following key operation.

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



```
LinearReg
    a=0.54595623
    b=-0.4025436
    r=0.98401035
y=ax+b
```

Single variable regression parameters are displayed.

Next, you can use the following.

F1 (X) .... Linear regression
F2 (Med) .... Med-Med regression
F3 (X^2) .... Quadratic regression
F4 (X^3) .... Cubic regression
F5 (X^4) .... Quartic regression
F6 (▷) .... Next menu

F1 (Log) .... Logarithmic regression
F2 (Exp) .... Exponential regression
F3 (Pwr) .... Power regression
F6 (▷) .... Previous menu

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

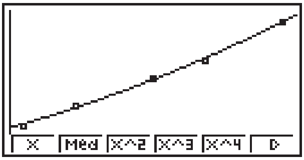
- Note that you cannot obtain estimated values for a Med-Med, quadratic regression, cubic regression, or quartic regression graph.

Example **To perform power regression using the following 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*)

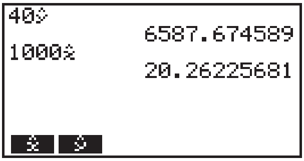
OPTN F5 (STAT) F2 ($\hat{y}$) EXE

```
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

You can perform probability distribution calculations in the **RUN Mode**. Pressing OPTN in the RUN Mode displays a menu of probability distribution functions.

OPTN F6 (▷) F3 (PROB) F6 (▷)

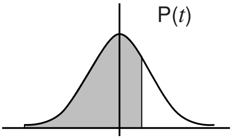
F1 (P() .... Calculation of probability P(t) value

F2 (Q() .... Calculation of probability Q(t) value

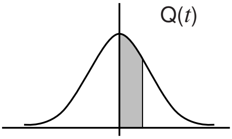
F3 (R() .... Calculation of probability R(t) value

F4 (t() .... Calculation of normalized variate $t(x)$ value

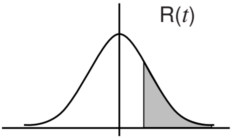
- Probability P(t), Q(t), and R(t), and normalized variate $t(x)$ are calculated using the following formulas.



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



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



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

$t(x)$

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

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

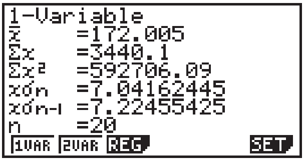
1. In the **STAT Mode**, input the height data into List 1 and the frequency data into List 2.

	List 1	List 2
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

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**.

4. In the **RUN Mode**, display the probability calculation menu.

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

OPTN F6(▷) F3(PROB) F6(▷)

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)

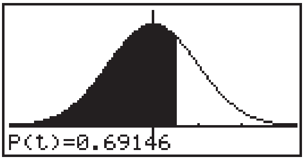
Probability Graphing

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

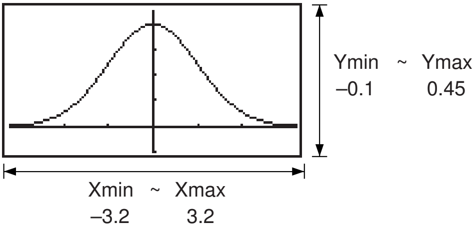
Example **To graph probability P(0.5)**

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.


Ymin ~ Ymax
–0.1 0.45

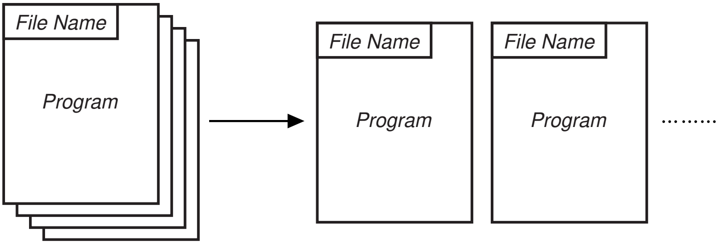
Xmin ~ Xmax
–3.2 3.2

Chapter 19

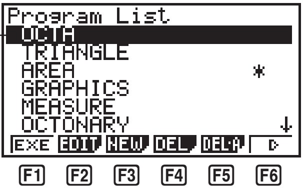
Programming

19-1 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.



```
Program List
 OCTA
 TRIANGLE
 AREA                 *
 GRAPHICS
 MEASURE
 OCTONARY             ↓
EXE EDIT NEW DEL DEL·A ▷
```

Selected memory area
(use ⏶ and ⏷ to move)

F1 (EXE) .... Execute program
F2 (EDIT) ...... Program edit
F3 (NEW) ...... New program
P.332 F4 (DEL) .... Specific program delete
P.332 F5 (DEL•A) .... Delete all
F6 (▷) .... Next menu

F6(▷)

```
SRC REN                ▷
```

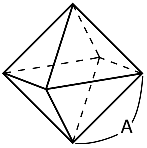
P.325 F1 (SRC) .... File name search
P.328 F2 (REN) .... File name change
F6 (▷) .... Previous menu

- 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.

19-2 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.

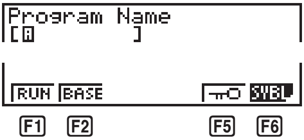
•To register a file name

Example **To register the file name OCTA**

- Note that a file name can be up to eight characters long.

1. While the program list is on the display, press F3 (NEW).

F3 (NEW)



```
Program Name
[A        ]
```

P.323

F1 (RUN) .... For input of general calculation programs
F2 (BASE) ..... For input of programs containing number base specifications
F5 (⊸O) .... Password registration
F6 (SYBL) ..... Symbol menu

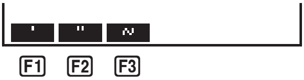
2. Input the name of the file.

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.
- P.5 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.

F6(SYBL)



- 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.

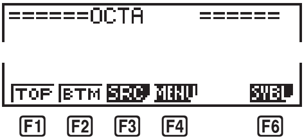
EXE

File name

- 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

Use the program input screen to input the contents of a program.

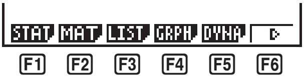


P.328 F1 (TOP) .... Top of program
P.328 F2 (BTM) .... Bottom of program
P.327 F3 (SRC) .... Search
F4 (MENU) .... Mode menu
F6 (SYBL) ..... Symbol menu

•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. 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.

F4(MENU)



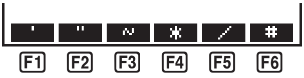
F6(▷)

- The following menu appears whenever you press F4 (MENU) while inputting a program that involves number base specifications.

F4(MENU)

- Pressing F6 (SYBL) displays a menu of symbols that can be input into a program.

F6(SYBL)



P.5

- Pressing SHIFT SET UP displays a menu of commands that can be used to change set up screen settings inside a program. For details on each of these commands, see “To change a mode set up”.

SHIFT SET UP

F6(▷)

F6(▷)

F6(▷)

The following function key menu appears if you press SHIFT SET UP while inputting a program that contains binary, octal, decimal, or hexadecimal calculation.

SHIFT SET UP

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> x^2 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 x^2 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>.

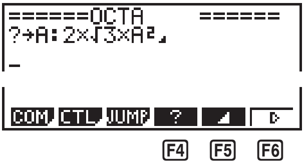
◢ **:** This command pauses program execution and displays the last calculation result obtained or text. It is similar to pressing EXE in a manual calculation.

P.333

- 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 (◢)



```
======OCTA    ======
?→A:2×√3×A²◢
_
```

SHIFT √ 2 ÷ 3 × ALPHA A ^ 3

```
======OCTA    ======
?→A:2×√3×A²◢
√2÷3×A^3_
```

SHIFT QUIT or EXIT EXIT

```
Program List
 OCTA
```

•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
```

F1

F1 (EXE) or EXE

```
?
```

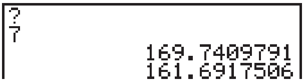
7 EXE

(Value of A)

```
?
7
                169.7409791
                   - Disp -
```

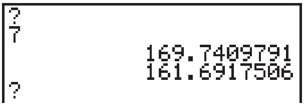
Intermediate result produced by ◢

EXE



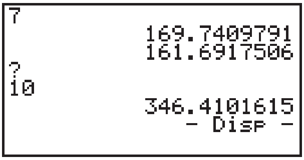
```
?
7
                169.7409791
                161.6917506
```

EXE



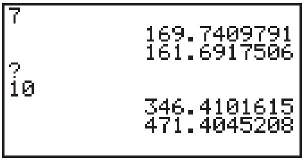
```
?
7
                169.7409791
                161.6917506

?
```

1 0 EXE



```
7
                169.7409791
                161.6917506
?
10
                346.4101615
                   - Disp -
```

EXE



```
7
             169.7409791
             161.6917506
?
10
             346.4101615
             471.4045208
```

⋮

P.334

- 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 (Go ERROR) occurs if the program specified by Prog "<file name>" cannot be found.

19-3 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.399

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.

P.323

- 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.328

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.

19-4 Calculating the Number of Bytes Used by a Program

This unit comes with 26 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.

P.28

- You can check how much memory has been used and how much remains at any time by selecting the **MEM** icon in the Main Menu and entering the MEM Mode. See “Memory Status (MEM)” for details.

19-5 Secret Function

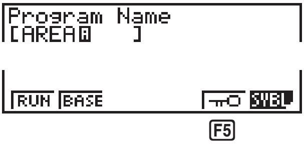
When inputting a program, you can protect it with a password that limits access to the program contents to those who know the password. Password protected programs can be executed by anyone without inputting the password.

•To register a password

Example **To create a program file under the name AREA and protect it with the password CASIO**

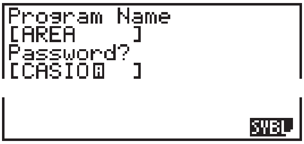
1. While the program list is on the display, press F3 (NEW) and input the file name of the new program file.

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▮   ]

P.315

- 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.

SHIFT QUIT


Program List
DATA
AREA *

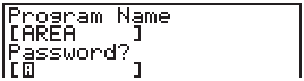
•To recall a program

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).

F2(EDIT)



```
Program Name
[AREA    ]
Password?
[A         ]
```

3. Input the password and press EXE to recall the program.

- The message "**Mismatch**" appears if you input the wrong password.

19-6 Searching for a File

You can search for a specific file name using any of the three following methods.

- Scroll Search — scroll through the file names in the program list.
- File Name Search — input the name of the file.
- Initial Character Search — input the first few letters of the name of the file.

•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
 TRIANGLE
 AREA                 *
 GRAPHICS
 MEASURE
 OCTONARY             ↓
EXE EDIT NEW DEL DEL·A ▷
```

F2

2. When the highlighting is located at the name of the file you want, press F2 (EDIT) to recall it.

F2(EDIT)

```
======OCTA    ======
?→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**

P.323

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█    ]
```

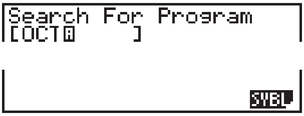
2. Press EXE to recall the program.
   - If there is no program whose file name matches the one you input, a new file is created using the input name.

•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.

EXE


Program List
OCTA
OCTONARY

- 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.

19-7 Searching for Data Inside a Program

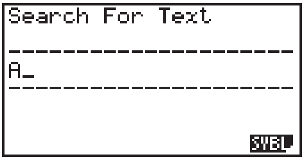
Example **To search for the letter “A” inside the program named OCTA**

1. Recall the program, press F3 (SRC), and input the data you want to search for.

```
======OCTA     ======
?→A:2×√3×A²◢
√2÷3×A^3
```

F3

F3(SRC)
ALPHA A

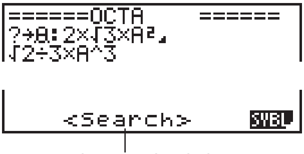


```
Search For Text
---------------------
A_
---------------------
```

- You cannot specify the newline symbol (↵) or display command (◢) for the search data.

2. 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.

EXE



```
======OCTA     ======
?→A:2×√3×A²◢
√2÷3×A^3

     <Search>
```

Indicates search operation is in progress

3. 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.

19-8 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).

F6(▷)F2(REN)

```
Rename
[■RIANGLE]

                    SYBL
```

2. Make any changes you want.

DEL DEL DEL

```
Rename
[ANGLE   ]
```

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.

P.23

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.

F1 (TOP) .... Moves the cursor to the top of the program

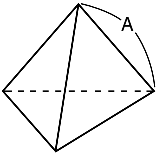
```
======OCTA    ======
?→A:2×√3×A²↵
√2÷3×A^3
```

F2 (BTM) .... Moves the cursor to the bottom of the program

```
======OCTA    ======
?→A:2×√3×A²↵
√2÷3×A^3_
```

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 ÷ $\underline{\text{1 2}}$ × 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 .... $\utilde{\text{2 ×}}$ SHIFT √ 3 × ALPHA A x^2 F6 (▷) F5 (◢)
Volume V .... SHIFT √ 2 ÷ $\underline{\text{3}}$ × 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

F6 (▷) F2 (REN) T E T R A

Rename
[TETRA■]

EXE

```
Program List
 TETRA

EXE EDIT NEW DEL DEL·A ▷
```

F2

2. Edit the program contents.

F2(EDIT)

```
======TETRA    ======
?→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

```
Program List
 TETRA

EXE EDIT NEW DEL DEL·A ▷
```

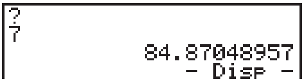
F1

F1 (EXE) or EXE

```
?
```

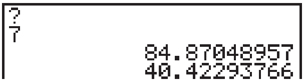
7 EXE

(Value of A)



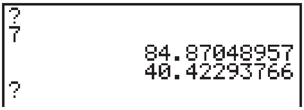
```
?
7
          84.87048957
            - Disp -
```

EXE



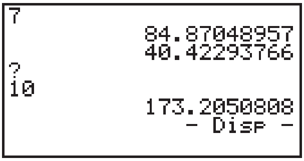
```
?
7
          84.87048957
          40.42293766
```

EXE



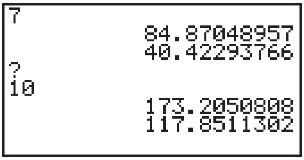
```
?
7
               84.87048957
               40.42293766
?
```

1 0 EXE



```
7
               84.87048957
               40.42293766
?
10
               173.2050808
                   - Disp -
```

EXE



```
7
               84.87048957
               40.42293766
?
10
               173.2050808
               117.8511302
```

⋮

19-9 Deleting a Program

There are two different ways to delete a file name and its program.

- Specific program delete
- All program delete

•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).

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).

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 **MEM Mode**. See “Clearing Memory Contents” for details.

P.30

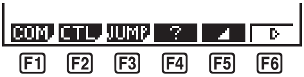
19-10 Useful Program Commands

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.

SHIFT PRGM



F1 (COM) ...... Program command menu
F2 (CTL) .... Control command menu
F3 (JUMP) ..... Jump command menu
F4 (?) .... Input command
F5 (◢) .... Output command
F6 (▷) .... Next menu

F6(▷)

F1 (CLR) .... Clear command menu
F2 (DISP) ...... Display command menu
F3 (REL) .... Conditional jump relational operator menu
F4 (I/O) .... Input/output command menu
F5 (:) .... Multi-statement command
F6 (▷) .... Previous menu

Program Command Menu (COM)

While the program menu is on the display, press F1 (COM) to display the program command menu.

F1(COM)

F1 (If) .... If command
F2 (Then) ...... Then command
F3 (Else) .... Else command
F4 (I•End) ...... IfEnd command
F6 (▷) .... Next menu

F6(▷)

F1 (For) .... For command
F2 (To) .... To command
F3 (Step) .... Step command
F4 (Next) .... Next command
F6 (▷) .... Next menu

F6(▷)

F1 (Whle) ...... While command
F2 (WEnd) ..... WhileEnd command
F3 (Do) .... Do command
F4 (Lp•W) ...... LpWhile command
F6 (▷) .... Previous menu

Control Command Menu (CTL)

While the program menu is on the display, press F2 (CTL) to display the control command menu.

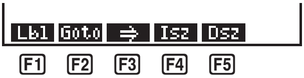
F2(CTL)

F1 (Prog) .... Prog command
F2 (Rtrn) .... Return command
F3 (Brk) .... Break command
F4 (Stop) .... Stop command

Jump Command Menu (JUMP)

While the program menu is on the display, press F3 (JUMP) to display the jump command menu.

F3(JUMP)



F1 (Lbl) .... Lbl command
F2 (Goto) .... Goto command
F3 (⇒) .... ⇒ (jump) command
F4 (Isz) .... Isz command
F5 (Dsz) .... Dsz command

Clear Command Menu (CLR)

While the program menu is on the display, press F6 (▷) F1 (CLR) to display the clear command menu.

F6(▷)F1(CLR)

F1 (Text) .... ClrText command

F2 (Grph) ...... ClrGraph command

F3 (List) .... ClrList command

Display Command Menu (DISP)

While the program menu is on the display, press F6 (▷) F2 (DISP) to display the display command menu.

F6(▷)F2(DISP)

F1 (Stat) .... DrawStat command

F2 (Grph) ...... DrawGraph command

F3 (Dyna) ...... DrawDyna command

F4 (F•Tbl) ...... Table & Graph command menu

F5 (R•Tbl)...... Recursion calculation and recursion formula graph command menu

Pressing F4 (F•Tbl) while the display command menu is on the display causes the Table & Graph command menu to appear.

F4(F•Tbl)

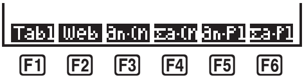
F1 (Tabl) .... DispF-Tbl command

F2 (G•Con) .... DrawFTG-Con command

F3 (G•Plt) ...... DrawFTG-Plt command

Pressing F5 (R•Tbl) while the display command menu is on the display causes the recursion calculation and recursion formula graph command menu to appear.

F5(R•Tbl)

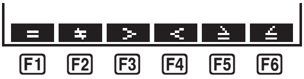


F1 (Tabl) .... DispR-Tbl command
F2 (Web) .... DrawWeb command
F3 (an•Cn) ..... DrawR-Con command
F4 (Σa•Cn) .... DrawRΣ-Con command
F5 (an•Pl) ...... DrawR-Plt command
F6 (Σa•Pl) ...... DrawRΣ-Plt command

Conditional Jump Relational Operator Menu (REL)

While the program menu is on the display, press F6 (▷) F3 (REL) to display the conditional jump relational operator menu.

F6(▷)F3(REL)



F1 (=) .... Relational operator =
F2 (≠) .... Relational operator ≠
F3 (>) .... Relational operator >
F4 (<) .... Relational operator <
F5 (≥) .... Relational operator ≥
F6 (≤) .... Relational operator ≤

Input/Output Commands Menu (I/O)

While the program menu is on the display, press F6 (▷) F4 (I/O) to display the input/output command menu.

F6(▷)F4(I/O)

F1 (Lcte) .... Locate command
F2 (Gtky) .... Getkey command
F3 (Send) ...... Send (command
F4 (Recv) ...... 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.

19-11 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:

$$\text{If} \quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}} \left\{\begin{array}{c} ↵ \\ : \\ ◢ \end{array}\right\} \text{Then <statement>} \left[\left\{\begin{array}{c} ↵ \\ : \\ ◢ \end{array}\right\} \text{<statement>} \right]$$

Parameters: condition, numeric expression

Description:

1. The Then-statement is executed only when the 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 (Syn 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:

$$\text{If} \quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}} \left\{\begin{array}{c} ↵ \\ : \\ ◢ \end{array}\right\} \text{Then <statement>}$$

$$\left[\left\{\begin{array}{c} ↵ \\ : \\ ◢ \end{array}\right\} \text{<statement>} \right] \left\{\begin{array}{c} ↵ \\ : \\ ◢ \end{array}\right\} \text{IfEnd}$$

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:

$$\text{If}\quad \underset{\text{numeric expression}}{\underline{\text{<condition>}}}\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{Then <statement>}\ \left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]$$

$$\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{Else <statement>}\ \left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{IfEnd}$$

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:

```
Lbl 1:? → A ↵
If A > 0 And A < 10 ↵
Then ”GOOD”↵
Else Goto 1 ↵
IfEnd
```

The above program displays the message “GOOD” whenever a value that is greater than zero and less than 10 is input. Any other value prompts for input again.

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:

For <starting value> → <control variable name> To <ending value> { ↵ : ◢ }

[<statement> { ↵ : ◢ }] 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 (Go 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:

Do { ↵ : ◢ } ~ 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:

$$\text{While <expression>} \left\{ \begin{array}{c} \text{↵} \\ : \\ \text{◢} \end{array} \right\} \sim \text{WhileEnd}$$

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.

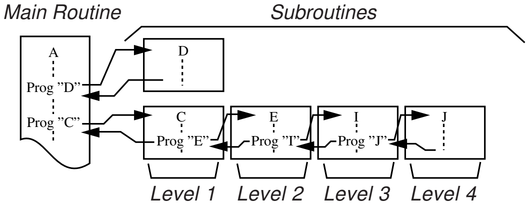
Syntax: Prog ”file name” ↵

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 (Go 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
```

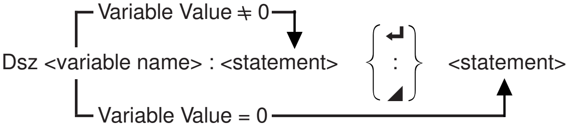
This program counts from 2 to 10. When the count reaches 5, however, it terminates execution and displays the message “STOP.”

■ 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 (Go ERROR) occurs.

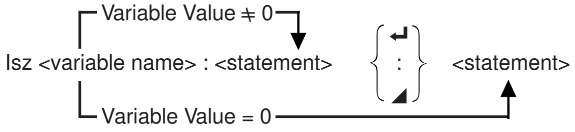
Example: ? → A : ? → B : Lbl 1 :
? → X : A × X + B ◢
Goto 1

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.

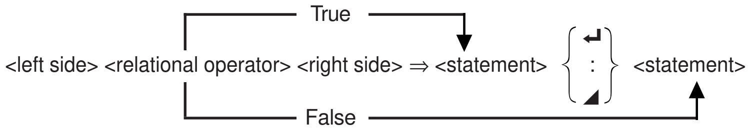
Description:

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)

P.352

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 ⇒ $\sqrt{\ }$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 $\Sigma a_n (\Sigma b_n)$ as the vertical axis and n as the horizontal axis.

Syntax:

DrawRΣ-Con ↵

DrawRΣ-Plt ↵

Description:

1. These commands graph recursion expressions, with $\Sigma a_n (\Sigma b_n)$ 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)

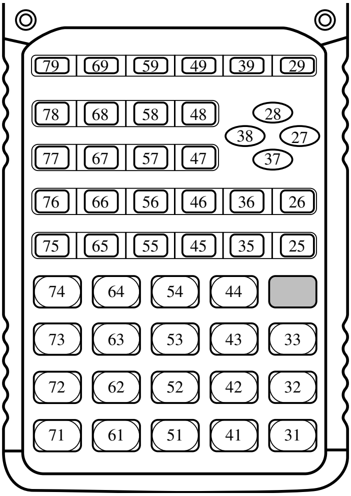
Getkey

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 FX”
This program displays the text “CASIO FX” 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> $\left\{\begin{array}{c}\text{↵}\\ :\\ \text{◢}\end{array}\right\}$ <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>

P.346

2. See "⇒ (Jump Code)" for details on using the conditional jump.

19-12 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.

P.92

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:**

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

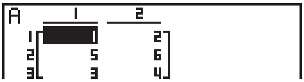
The following is the syntax to use for this program.

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.

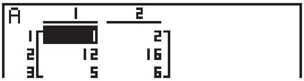
∗Row 4, A, 2

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.

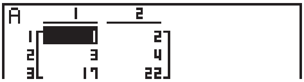
∗Row+ 4, A, 2, 3

Matrix name

Multiplier

Executing this program produces the following result.

(MAT Mode)



```
A      1      2
1 [    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**

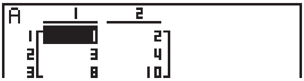
The following is the syntax to use for this program.

Row+ A, 2, 3

Matrix name

Executing this program produces the following result.

(MAT Mode)



```
A      1      2
1 [    1      2 ]
2 [    3      4 ]
3 [    8     10 ]
```

P.126

■ 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

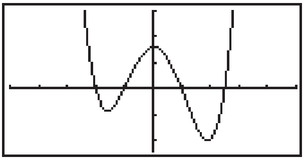
  DrawGraph↵

Example Program

①ClrGraph↵	① SHIFT PRGM F6 F1 F2
②View Window –10, 10, 2, –120, 150, 50↵	② SHIFT F3 F1 EXIT
③Y = Type↵	③ F4 F4 F3 F1
"X ^ 4–X ^ 3–24X^2 + 4X + 80" → $\underset{④}{\underline{\text{Y1}}}$↵	④ VARS F4 F1 EXIT EXIT

⑤G SelOn 1↵	⑤ F4 F4 F1 F1 EXIT
⑥DrawGraph	⑥ SHIFT PRGM F6 F2 F2

Executing this program produces the result shown here.



P.208

■ Using Dynamic Graph Functions in a Program

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.

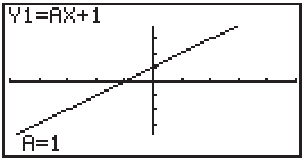
• Dynamic Graph range

1 → D Start↵
5 → D End↵
1 → D pitch↵

Example Program

ClrGraph↵	
View Window –5, 5, 1, –5, 5, 1↵	
Y = Type↵	
"AX + 1" → $\underset{①}{\underline{\text{Y1}}}$↵	① VARS F4 F1 EXIT EXIT
②D SelOn 1↵	② F4 F5 F1
③D Var A↵	③ F3
1 → ④D Start↵	④ VARS F5 F1
5 → ⑤D End↵	⑤ F2
1 → ⑥D pitch↵	⑥ F3
⑦DrawDyna	⑦ SHIFT PRGM F6 F2 F3

Executing this program produces the result shown here.



⋮ ↑
↓ ⋮

P.236

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.

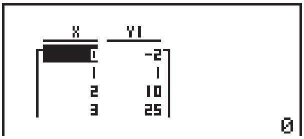
- Table range setting
  - 1 → F Start↵
  - 5 → F End↵
  - 1 → F pitch↵
- Numeric table generation
  - DispF-Tbl↵
- Graph draw operation
  - Connect type: DrawFTG-Con↵
  - Plot type: DrawFTG-Plt↵

Example Program

ClrGraph↵	
ClrText↵	
View Window 0, 6, 1, –2, 106, 2↵	
Y = Type↵	
”$3X^2$ – 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

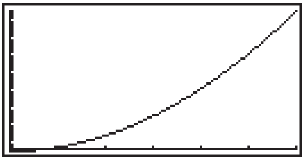


X	Y1
0	-2
1	1
2	10
3	25

0

Graph

EXE



P.250

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↵

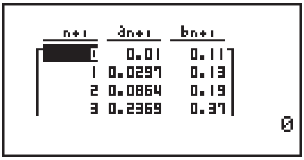
Example Program

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 → ③ R 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

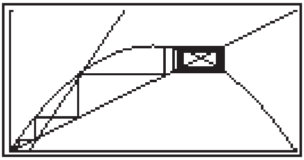
[EXE]



```
  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
                        0
```

Recursion graph

[EXE]



P.265

■ Using List Sort Functions in a Program

These functions let you sort the data in lists into ascending or descending order.

- Ascending order

  ① ②
  SortA (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)

P.284

■ 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

P.286

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 *x*, *y* line graph.

  S-Gph1 DrawOn, Scatter, List1, List2, 1, Square ↵

  In the case of an *x*, *y* line graph, replace “Scatter” in the above specification with “*xy*Line”.

- The following is a typical graph condition specification for a single-variable graph.

  S-Gph1 DrawOn, Hist, List1, List2 ↵

  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.289

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 ↵

  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.289

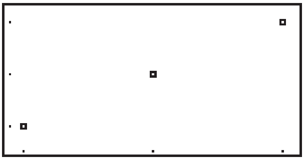
Linear Regression:	Linear
Med-Med:	Med-Med
Quadratic Regression:	Quad
Cubic Regression:	Cubic
Quartic Regression :	Quart
Logarithmic Regression:	Log
Exponential Regression:	Exp
Power Regression :	Power

Example Program

```
ClrGraph ↵
①
S-Wind Auto ↵
                ②
{1, 2, 3} → List  1 ↵
                ③
{1, 2, 3} → List  2 ↵
④           ⑤           ⑥                           ⑦
S-Gph1 DrawOn, Scatter, List1, List2, 1, Square ↵
⑧
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 SHIFT PRGM F6 F2 F1

Executing this program produces the scatter diagram shown here.



Performing Statistical Calculations

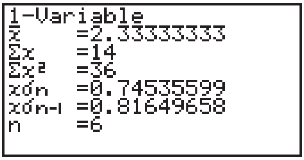
- Single-variable statistical calculation

① 1-Variable List1, List2

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
```

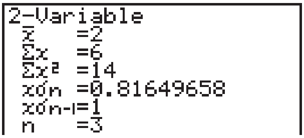
- Paired-variable statistical calculation

2-Variable List1, List2, List3

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 List1, List2, List3

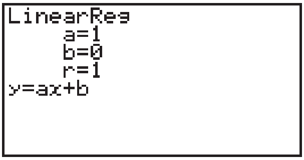
*Calculation type**

Frequency data (Frequency)

y-axis data (YList)

x-axis data (XList)

① F4 F1 F6 F6 F1



```
LinearReg
    a=1
    b=0
    r=1
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

Chapter 20

Data Communications

This chapter tells you everything you need to know to transfer programs between the fx-9750G and certain CASIO Graphic Scientific Calculator models 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.

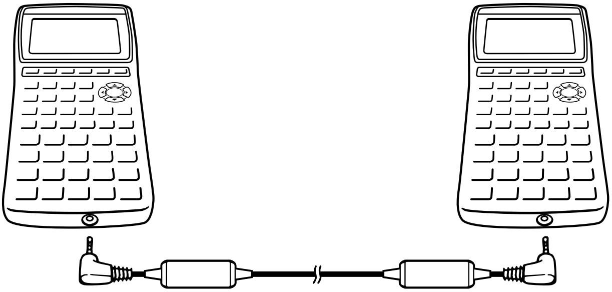
This chapter also contains information on how to use the optional SB-62 cable to connect to a CASIO Label Printer to transfer screen data for printing.

20-1 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.

20-2 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.

•To connect the unit with a personal computer

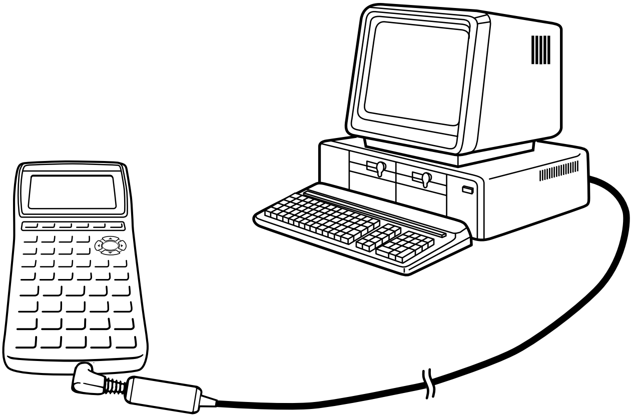
1. Check to make sure that the power of the unit and the personal computer is off.

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. Switch on the power of the unit, followed by the personal computer.
   - After you finish data communications, switch off power in the sequence: the unit first, and then the personal computer. Finally, disconnect the equipment.



20-3 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 Manual 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 October 1996).

•To connect the unit with a Label Printer

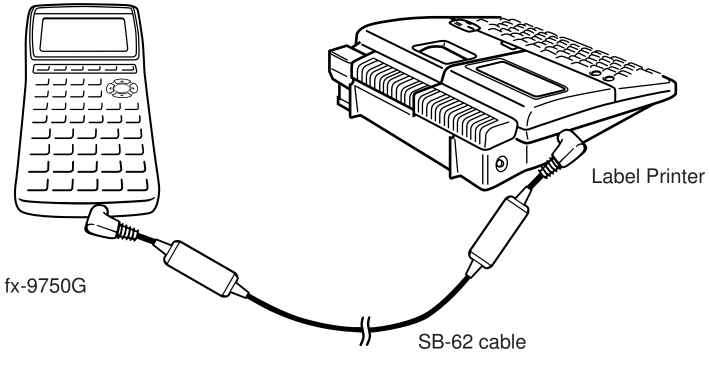
1. Check to make sure that the power of the unit and the Label Printer is off.

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.

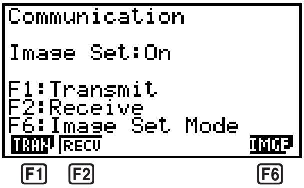
5. Switch on the power of the unit, followed by the Label Printer.



- After you finish data communications, switch off power in the sequence: the unit first, and then the Label Printer. Finally, disconnect the equipment.

20-4 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:On

F1:Transmit
F2:Receive
F6:Image Set Mode

P.372

Image Set:Off ...... Indicates the status of the graphic image send features.
Off: Graphic images not sent.
On: Pressing F↔D sends graphic images.

F1 (TRAN) ..... Menu of send settings
F2 (RECV) .... Menu of receive settings
F6 (IMGE) ..... Menu of graphic image transfer settings

Communications parameters are fixed at the following settings.

- Speed (BPS): 9600 bits per second
- Parity (PARITY): NONE

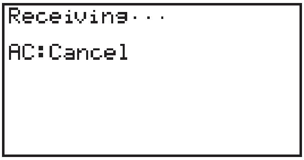
20-5 Performing a Data Transfer Operation

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.

F2(RECV)



Receiving···

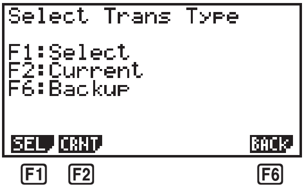
AC:Cancel

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.

F1 (TRAN)



Select Trans Type

F1:Select
F2:Current
F6:Backup

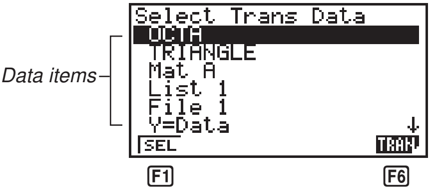
Press the function key that corresponds to the type of data you want to send.

- F1 (SEL) .... Selects data items and sends
- F2 (CRNT) .... Selects data items from among previously selected data items and sends
- F6 (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.

F1(SEL) or F2(CRNT)



Select Trans Data
DATA
TRIANGLE
Mat A
List 1
File 1
Y=Data

F1 (SEL) .... Selects data item where cursor is located.

F6 (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.

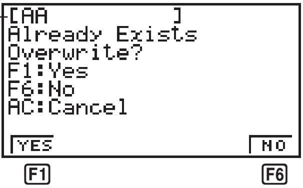
Only items that contain data appear on the data item selection screen. If there are too many data items to fit on a single screen, the list scrolls when you move the cursor to the bottom line of the items on the screen.

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.

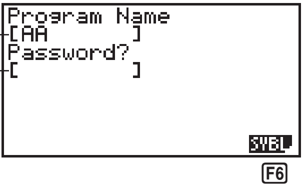

Data item name

```
[AA        ]
Already Exists
Overwrite?
F1:Yes
F6:No
AC:Cancel
```

F1 (YES) .... Replaces the receiving unit's existing data with the new data.

F6 (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?
[          ]
```

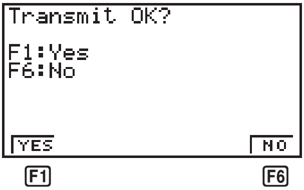
F6 (SYBL) ..... Symbol input

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.

F6(TRAN)



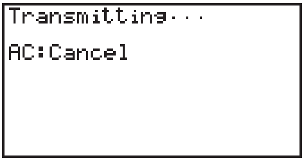
```
Transmit OK?

F1:Yes
F6:No
```

F1 (YES) .... Sends data.

F6 (NO) .... Returns to data selection screen.

Press F1 (YES) to send the data.

F1(YES)



```
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]

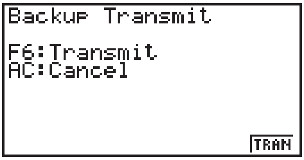
Press AC to return to the data communication main menu.

•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 F6 (BACK), and the back up send menu shown below appears.

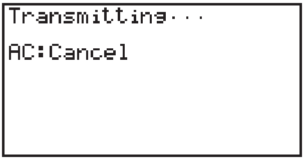
F6(BACK)


Backup Transmit
F6:Transmit
AC:Cancel

F6

Press F6 (TRAN) to start the send operation.

F6(TRAN)


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 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.

20-6 Screen Send Function

The following procedure sends a bit mapped screen shot of the display to a connected computer.

•To send the screen

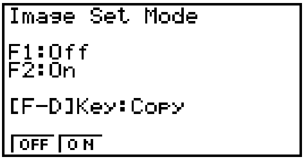
P.365

1. Connect the unit to a personal computer or to a CASIO Label Printer.

P.366

2. In the data communication main menu, press F6 (IMGE), and then select “On” for Image Set.

F6(IMGE)



```
Image Set Mode

F1:Off
F2:On

[F-D]Key:Copy

OFF  ON
```

F1 F2

F1(OFF) .... Graphic images not sent

F2(ON) .... Bit map

3. Display the screen you want to send.

4. 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.

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.

20-7 Data Communications Precautions

Note the following precautions whenever you perform data communications.

- A TRANSMIT 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.

- A RECEIVE 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.

- A TRANSMIT ERROR or RECEIVE 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.

- A MEMORY FULL 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 21

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).

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	Step	Key operation	Display
1	F1 (EXE)	M?	11	EXE	83
2	119 EXE	7	12	EXE	END
3	EXE	17	13	EXE	M?
4	EXE	END	14	262701 EXE	3
5	EXE	M?	15	EXE	3
6	440730 EXE	2	16	EXE	17
7	EXE	3	17	EXE	17
8	EXE	3	18	EXE	101
9	EXE	5	19	EXE	END
10	EXE	59	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	:	√	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																			
17																			
18																			
19																			
20																			
21																			
22																			
23																			
24																			
25																			
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			

Program for **t-Test Value**

No. **3**

Description

The mean (sample mean) and sample standard deviation can be used to obtain a t-test value.

$$t = \frac{(\overline{x} - m)}{\dfrac{x\sigma_{n-1}}{\sqrt{n}}}$$

$\overline{x}$: 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.

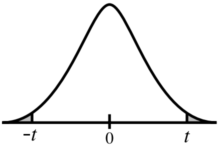
No. **3**

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

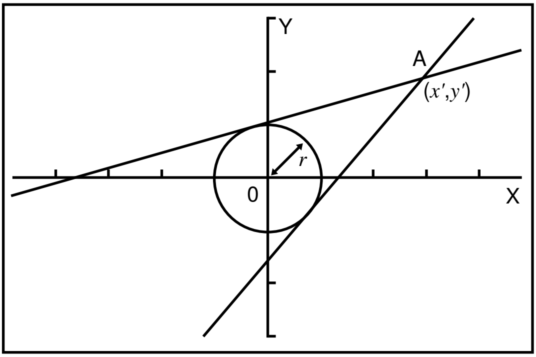
P (Probability) / Degree of Freedom	0.2	0.1	0.05	0.01
1	3.078	6.314	12.706	63.657
2	1.886	2.920	4.303	9.925
3	1.638	2.353	3.182	5.841
4	1.533	2.132	2.776	4.604
5	1.476	2.015	2.571	4.032
6	1.440	1.943	2.447	3.707
7	1.415	1.895	2.365	3.499
8	1.397	1.860	2.306	3.355
9	1.383	1.833	2.262	3.250
10	1.372	1.812	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 **Circle and Tangents**

No. **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 (Ma 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	↵					

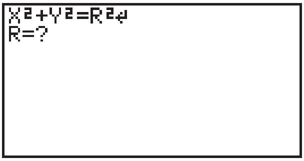
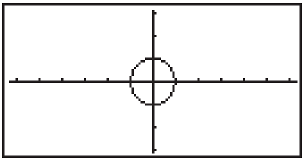
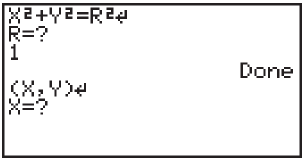
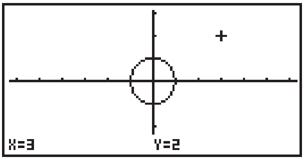
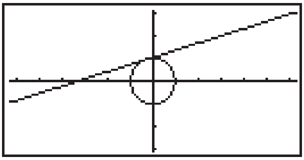
No.
4

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

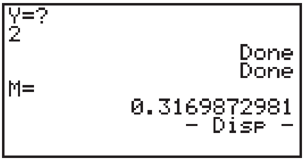
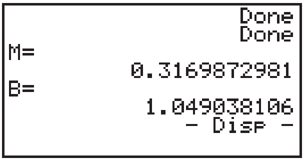
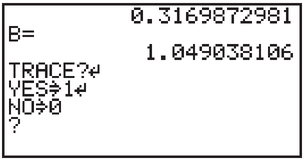
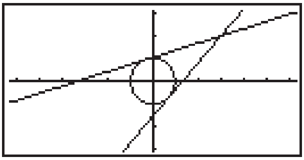
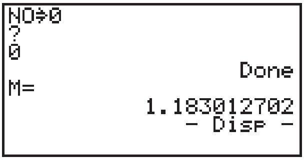
No. **4**

Step	Key Operation	Display
1	F1 (EXE)	 $X^2+Y^2=R^2$↵ R=?
2	1 EXE	
3	EXE	 $X^2+Y^2=R^2$↵ R=? 1 Done (X,Y)↵ X=?
4	3 EXE 2 EXE	
5	EXE	

Program for

Circle and Tangents

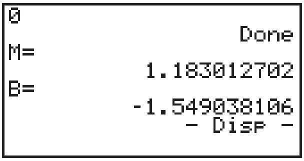
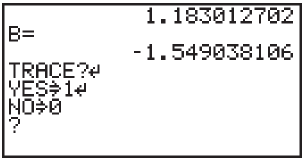
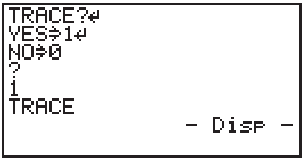
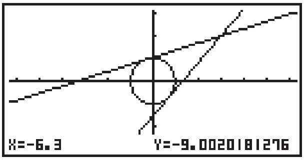
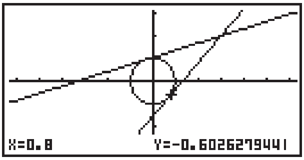
No. **4**

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

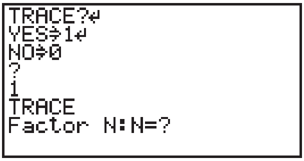
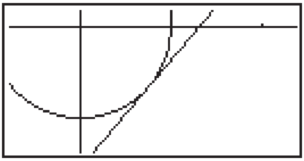
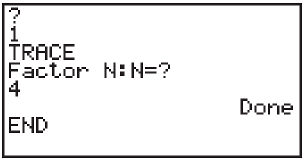
No. 4

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**

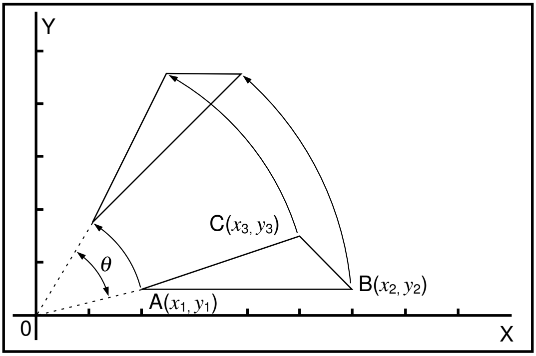
Step	Key Operation	Display
16	EXE	 TRACE?↵ YES⇒1↵ NO⇒0 ? 1 TRACE Factor N:N=?
17	4 EXE	
18	EXE	 ? 1 TRACE Factor N:N=? 4 Done END

CASIO PROGRAM SHEET

Program for **Rotating a Figure**

No. **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			

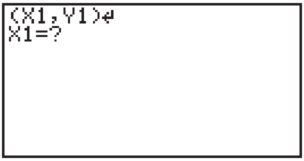
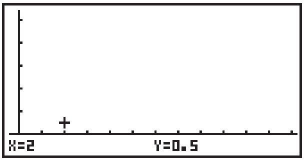
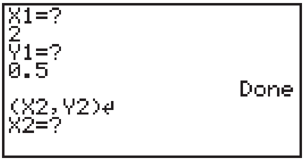
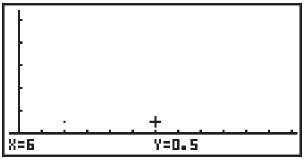
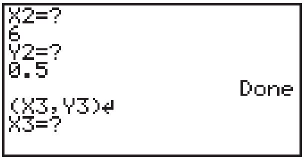
No. **5**

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

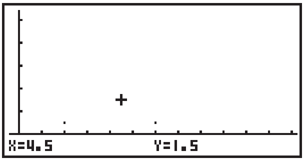
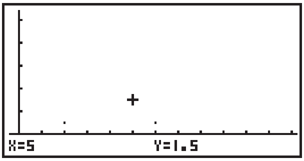
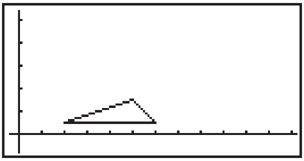
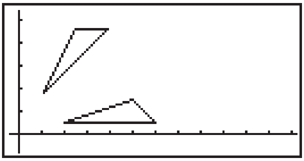
No. 5

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	 X=4.5 Y=1.5
7	▶ ~ ▶ (Locate the pointer at X = 5)	 X=5 Y=1.5
8	EXE	
9	EXE	 X3=? 4.5 Y3=? 1.5 Done Done ANGLE:Deg?
10	45 EXE	

Continue, repeating from step 8.

Appendix

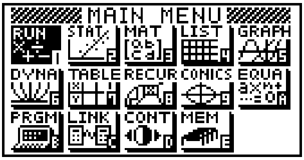
Appendix A Resetting the Calculator

Warning!

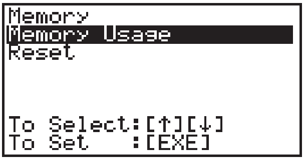
The procedure described here clears all memory contents. Never perform this operation unless you want to totally clear the memory of the calculator. If you need the data currently stored in memory, be sure to write it down somewhere before performing the RESET operation.

•To reset the calculator

1. Press MENU to display the main menu.



2. Highlight the **MEM** icon and press EXE, or press $\overset{\text{E}}{\text{COS}}$.

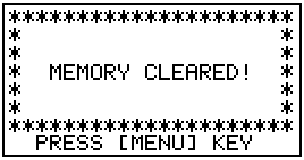


```
Memory
Memory Usage
Reset



To Select:[↑][↓]
To Set   :[EXE]
```

3. Use ▼ to move the highlighting down to “Reset” and then press EXE.

```
**********************
*       RESET        *
**********************

RESET ALL MEMORIES?

[F1]              [F6]
YES   RESET ALL   N O
```

4. Press F1 (YES) to reset the calculator or F6 (NO) to abort the operation without resetting anything.



```
**********************
*                    *
*                    *
*  MEMORY CLEARED!   *
*                    *
*                    *
**********************
  PRESS [MENU] KEY
```

5. Press MENU.

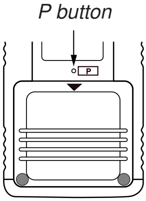
P.13

- If the display appears to dark or dim after you reset the calculator, adjust the contrast.

Resetting the calculator initializes it to the following settings.

Item	Initial Setting
Icon	RUN
Mode	Comp
Angle Unit	Rad
Exponent Display Range	Norm 1
Variable Memory	Clear
Function Memory	Clear
Answer Memory (Ans)	Clear
Graphic Display/Text Display	Clear
Matrix Contents	Clear
Equation Calculation Memory	Clear
View Window	Clear (initialized)
View Window Memory	Clear
Graph Function	Clear
Graph Memory	Clear
Enlargement/Reduction Factor	Clear (initialized)
Dynamic Graph Data	Clear
Table & Graph Data	Clear
Recursion Calculation Memory	Clear
List Data	Clear
Statistical Calculation/Graph Memory	Clear
Program	Clear
Input Buffer/AC Replay	Clear

- 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.

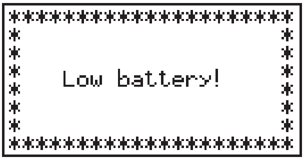


- Pressing the P button while an internal calculation is being performed (indicated by a blank display) will cause all data in memory to be deleted.

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 switch power off, in order to protect memory contents. You will not be able to switch 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.

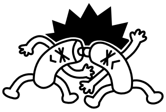
■ Replacing Batteries

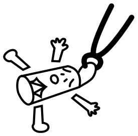
Precautions:

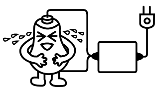
Incorrectly using batteries can cause them to burst or leak, possibly damaging the interior of the unit. Note the following precautions:

- 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 replace the main power supply battery compartment cover or switch 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.

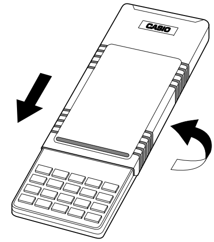
* Be sure to replace all four batteries with new ones.

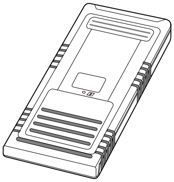
1. Press SHIFT OFF to turn the calculator off.

Warning!

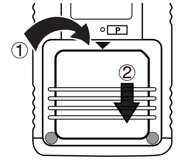
* Be sure to switch the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.

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.



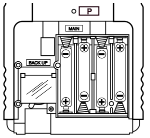


3. Remove the back cover from the calculator by pressing it in the direction indicated by arrow ①, and then sliding it in the direction indicated by arrow ②.



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 contrast.

•To replace the memory back up battery

* Before replacing the memory back up battery, switch 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.

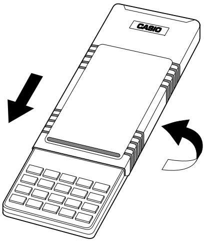
* Be sure to replace the back up power supply battery at least once 2 years, regardless of how much you use the unit during that time. Failure to do so can cause data in memory to be deleted.

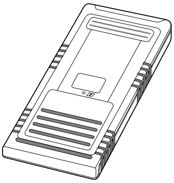
1. Press SHIFT OFF to turn the calculator off.

Warning!

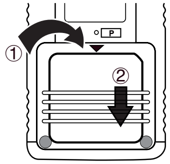
* Be sure to switch the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.

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.



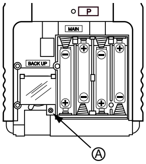


3. Remove the back cover from the calculator by pressing it in the direction indicated by arrow ①, and then sliding it in the direction indicated by arrow ②.



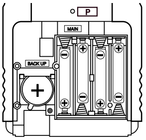
4. Remove screw Ⓐ on the back of the calculator, and remove the back up battery compartment cover.

5. 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 switches 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 $\sum$ calculation results. ⑤ Poor precision in differential calculation results. ⑥ Poor precision in integration calculation results. ⑦ Cannot find results of equation calculations.	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 using a larger value for n (number of partitions). ⑦ Check the coefficients of the equation.
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.

Appendix C Error Message Table

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 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.

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 $\lvert x\rvert \neq \pi/2(2n+1)$: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}	-1×10^{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)	$0 \leqq r < 1 \times 10^{100}$ (DEG) $\lvert\theta\rvert < 9 \times 10^{9\circ}$ (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 $\lvert\theta\rvert \neq \pi/2(2n+1)$:RAD $\lvert\theta\rvert \neq 100(2n+1)$:GRA
$\circ\ '\ ''$	$\lvert a\rvert, b, c < 1 \times 10^{100}$ $0 \leqq b, c$	"	"	
$\overleftarrow{\circ\ '\ ''}$	$\lvert x\rvert < 1 \times 10^{100}$ Sexagesimal display: $\lvert x\rvert \leqq 1 \times 10^{7}$			
^(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) 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) However; $-1 \times 10^{100} < \frac{1}{x}\log\lvert y\rvert < 100$	"	"	
a^{b}/c	• Results Total of integer, numerator and denominator must be within 10 digits (includes division marks). • Input Result displayed as a fraction for integer when integer, numerator and denominator are less than 1×10^{10}.	"	"	
STAT	$\lvert x\rvert < 1 \times 10^{50}$ $\lvert y\rvert < 1 \times 10^{50}$ $\lvert n\rvert < 1 \times 10^{100}$ $x\sigma_{n}, y\sigma_{n}, \bar{x}, \bar{y}, a, b, c, d, e, r$: $n \neq 0$ $x\sigma_{n-1}, y\sigma_{n-1}$: $n \neq 0, 1$	"	"	

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 2-byte Command Table

Spaces in the following commands are indicated by "⊔".

Commands available with the PRGM key

If⊔, Then⊔, Else⊔, IfEnd, For⊔, ⊔To⊔, ⊔Step⊔, Next, While⊔, WhileEnd, Do, LpWhile⊔, Return, Break, Stop, Locate⊔, Send(, Getkey, Receive(, ClrText, ClrGraph, ClrList, DrawGraph, DrawDyna, DrawStat, DrawFTG-Con, DrawFTG-Plt, DrawR-Con, DrawR-Plt, DrawRΣ-Con, DrawRΣ-Plt, DrawWeb⊔, DispF-Tbl, DispR-Tbl

Commands available with the MENU key in the PRGM Mode

1-Variable⊔, 2-Variable⊔, LinearReg⊔, Med-MedLine⊔, QuadReg⊔, CubicReg⊔, QuartReg⊔, LogReg⊔, ExpReg⊔, PowerReg⊔, S-Gph1⊔, S-Gph2⊔, S-Gph3⊔, Square, Cross, Dot, Scatter, xyLine, Hist, MedBox, MeanBox, N-Dist, Broken, Linear, Med-Med, Quad, Cubic, Quart, Log, Exp, Power, Y=Type, r=Type, ParamType, X=cType, Y>Type, Y<Type, Y≧Type, Y≦Type, D⊔Var⊔, a_nType, a_{n+1}Type, a_{n+2}Type, StoGMEM⊔, RclGMEM⊔, SortA(, SortD(, G⊔SelOn⊔, G⊔SelOff⊔, T⊔SelOn⊔, T⊔SelOff⊔, D⊔SelOn⊔, D⊔SelOff⊔, R⊔SelOn⊔, R⊔SelOff⊔, DrawOn, DrawOff, List1, List2, List3, List4, List5, List6

VARS menu commands

D⊔Start, D⊔End, D⊔pitch, RightXmin, RightXmax, RightXscl, RightYmin, RightYmax, RightYscl, RightTθmin, RightTθmax, RightTθptch, Sim⊔Result, Ply⊔Result, Q_1, Q_3, x_1, y_1, x_2, y_2, x_3, y_3, X, c, d, e

Commands available with the SETUP key in the PRGM Mode

S-WindAuto, S-WindMan, G-Connect, G-Plot, DualGraph, DualGtoT, DualT+G, DualOff, BG-None, BG-Pict⊔, GridOff, GridOn, VarRange, FuncOn, FuncOff, SimulOn, SimulOff, AxesOn, AxesOff, CoordOn, CoordOff, LabelOn, LabelOff, DerivOn, DerivOff, ΣdispOn, ΣdispOff, VarList1, VarList2, VarList3, VarList4, VarList5, VarList6, File1, File2, File3, File4, File5, File6

Commands available with the SHIFT key

Graph⊔X=, StoV-Win⊔, RclV-Win⊔, Tangent⊔, Normal⊔, Inverse⊔, Vertical⊔, Horizontal⊔, Text⊔, Circle⊔, F-Line⊔, PlotOn⊔, PlotOff⊔, PlotChg⊔, PxlOn⊔, PxlOff⊔, PxlChg⊔, PxlTest⊔

OPTN menu commands

StoPict⊔, RclPict⊔, Max(, Min(, Mean(, Median(, d^2/dx^2(, Solve(, FMin(, FMax(, Seq(, Dim⊔, Fill(, Identity⊔, Augment(, List→Mat(, Mat→List(, Sum⊔, Prod⊔, Percent⊔, Cuml⊔, List⊔, ⊔And⊔, ⊔Or⊔, Not⊔

Commands available during recursion calculations

b_n, b_{n+1}, b_{n+2}, b_0, b_1, b_2, a_nStart, b_nStart, a_{n+2}, a_0, a_1, a_2

Appendix F Specifications

Model: fx-9750G

Calculations

Basic calculation functions:

Negative numbers; exponents; parenthetical addition, subtraction, multiplication, division (with priority sequence judgement function - true algebraic logic)

Built-in scientific functions:

Trigonometric/inverse trigonometric functions (angle units: degrees, radians, grads); hyperbolic/inverse hyperbolic functions; logarithmic/exponential functions; reciprocals; factorials; square roots; cube roots; powers; roots; squares; negative signing; exponential notation input; π; parenthetical calculations; internal rounding; random numbers; angle unit specification; fractions; decimal-sexagesimal conversion; coordinate transformation; engineering calculations; permutation; combination; logical operators (And, Or, Not); number of decimal place and significant digit specification; engineering notation symbols (11 types)

Built-in functions:

Exponential notation range; delete, insert, answer functions; replay; memory status display (bytes used/unused); multistatements; output command input

Solve Function: Extraction of function's root using Newton's Method

Maximum/minimum value calculation:

Extraction of function's maximum/minimum within a specific interval

Differentials:

Extraction of derivative using differential from center point

Quadratic differentials:

Extraction of quadratic differential using second order value differential formula

Integrations: Using Simpson's rule

Σ **Calculations:** Calculation of partial sum of sequence $\{a_n\}$

Complex number calculations:

Addition, subtraction, multiplication, division, reciprocal, square root, square, absolute number/argument calculations; conjugate complex number extraction; real number part/imaginary number part extraction

Binary, octal, decimal, hexadecimal calculations:

Addition, subtraction, multiplication, division; base specification; negative values (two's complement); logical operations

Matrix calculations:

Addition, subtraction, multiplication, division; scalar product; transposition; determinant; inversion; squaring; raising to a power; absolute value; integer/decimal part extraction; maximum integer; row operation; dimension specification/checking; identity matrix input; matrix fill, combination; assignment of column content to list file

Equation calculations:

Solution of linear equations with two to six unknowns, cubic and quadratic equations; recall of equation coefficients and solutions

List calculations:

Data sorting (ascending, descending); maximum value; minimum value; average, median; sum; sum of products; cumulative frequency; percent calculations; numeric sequence generation

Logical operations:

And, Or, Not

Variables: 28

Calculation range:

$\pm 1 \times 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ and 0. Internal operations use 15-digit mantissa.

Exponential display range: Norm 1: $10^{-2} > |x|, |x| \geqq 10^{10}$
Norm 2: $10^{-9} > |x|, |x| \geqq 10^{10}$

Rounding:

Performed according to the number of specified significant digits and decimal places.

Graph Functions

Built-in function graphs (rectangular and polar coordinates) **:**

(40 types) sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, log, ln, 10^x, e^x, x^2, $\sqrt{\ }$, $\sqrt[3]{\ }$, x^{-1}

Graph Types:

Rectangular coordinate:	$y = f(x)$
Polar coordinate:	$r = f(\theta)$
Parametric:	$(x, y) = (f(\mathrm{T}), g(\mathrm{T}))$
Inequality:	$(y > f(x), y < f(x), y \geqq f(x), y \leqq f(x))$
X = constant	
Integral	

Graph Function Memory:

Graph function storage, editing, selection, drawing, analysis (root, maximum and minimum, y-intercepts, intersects for two graphs, coordinate values at any point, derivative for any range)

Graph Functions:

View Window specification; trace; scroll; graph range specification; overwrite; zoom [box, factor (zoom in, zoom out), Auto V-Win, ORIG, SQR, RND, INTG, PRE]; View Window memory; graph memory; graph save; graph function display; graph background selection; simultaneous drawing of multiple graphs

Sketch Functions:

Plot; line; plot on/off; plot change; tangent line; normal line; inverse; circle; horizontal/vertical line; pen; pixel on/off; pixel change; pixel test; text; manual graph; clear screen

Dual Graph:

Range settings for left and right screens; drawing in main window; copy, swap

Graph-to-Table:

Split display for function (rectangular, polar, parametric) graph and table; storage of pointer coordinates in numeric table/list file

Dynamic Graph:

Storage, editing, drawing of Dynamic Graph functions (rectangular, polar, parametric); drawing speed control; Dynamic Graph memory; seven built in graph functions

Implicit Function Graph:

Drawing/analysis of 9 types (focus, vertex, latus rectum, center, radius, x/y-intercept, directrix, axis of symmetry, asymptote)

Table & Graph:

Input/editing of rectangular, polar, parametric function (up to 20 can be input); numeric table generation (from range or list file data); graph drawing; numeric table delete, insert, add

Recursion Calculations and Graph:

Storage/editing of two recursion types; numeric table generation; graphing; numeric table delete, insert, add; recursion formula convergence/divergence graph (WEB graph)

Statistics:

Standard deviation: number of data; mean; standard deviation (two types); sum; sum of squares; statistical calculations (mode, median, maximum, minimum, first quartile point, third quartile point); normal probability distribution; single-variable statistical graphs (histogram bar graph; box graph for mean and median; normal distribution curve; line graph)

Regression: number of data; mean of x; mean of y; standard deviation of x (two types); standard deviation of y (two types); sum of x; sum of y; sum of squares of x; sum of squares of y; sum of squares of x and y; constant term; regression coefficient; correlation coefficient; Med-Med calculations; regression graphs (linear regression graph; Med-Med graph; quadratic/cubic/quartic regression graph; logarithmic regression graph; exponential regression graph; power regression graph)

Plotting of scatter diagrams; drawing of xy line graphs

Programming

Input, storage, recall, execution of programs in program area; editing and deletion of file names and program contents; recall by file name; secret feature

Program commands:

Loop (If, For, Do, While); Control (Prog [subroutine], Stop, nesting up to 10 levels); Unconditional jump (Goto, Lbl); Conditional jump (⇒); Count jump (Isz, Dsz); Relational operators (=, ≠, >, <, ≥, ≤); Clear (ClrText, ClrGraph, ClrList); Display (function graph, statistical graph, Dynamic Graph, Table & Graph, recursion calculation and graph); I/O (Locate, Getkey, Send, Receive); Input (?); Output (◢); Delimiter (:)

General Commands:

Matrix (4); function graph (15); Dynamic Graph (3); function table (5); recursion table (13); list (2); statistical (42)

Check Function: program check, debugging, etc.

Program capacity: 26 kbytes (max.)

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: 2 bits

Receive: 1 bit

General

Display system:

21-character × 8-line liquid crystal display; 10-digit mantissa and 2-digit exponent for calculations: displays binary, octal, decimal, hexadecimal, sexagesimal, fraction, complex number values

Text display:

Up to 128 characters for function commands, program commands, alpha characters

Error check function:

Check for illegal calculations (using values greater than 10^{100}), illegal jumps, etc. Indicates by error message display.

Power supply:

Main: Four AAA-size batteries (LR03 (AM4) or R03 (UM-4))

Back-up: One CR2032 lithium battery

Power consumption: 0.06W

Battery life

Main:

LR03 (AM4):	Approximately 300 hours (continuous display of main menu)
	Approximately 2 years (power off)
R03 (UM-4):	Approximately 200 hours (continuous display of main menu)
	Approximately 2 years (power off)

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: 19.7 mm (H) × 83 mm (W) × 175.5 mm (D)
3/4" (H) × 3 1/4" (W) × 6 7/8" (D)

Weight: 190g (including batteries)

Index

Index

Index

Command Index

Key Index

Key	Primary Function	combined with SHIFT	combined with ALPHA
Trace F1	Turns trace function on/off. Selects 1st function menu item.		
Zoom F2	Turns zoom function on. Selects 2nd function menu item.		
V-Window F3	Displays View Window parameter input screen. Select 3rd function menu item.		
Sketch F4	Displays sketch menu. Selects 4th function menu item.		
G-Solv F5	Displays graph solve menu. Selects 5th function menu item.		
G ↔ T F6	Switches display between graph & text screens. Selects 6th function menu item.		
SHIFT	Activates shift functions of other keys and function menus.		
OPTN	Displays option menu.		
PRGM VARS	Displays the variable data menu.	Displays program command menu.	
SET UP MENU	Returns to the Main Menu.	Shows the set up display.	
A-LOCK ALPHA	Allows entry of alphanumeric characters shown in red.	Locks/Unlocks entry of alphanumeric characters.	
$\sqrt{\ }$ r x^2	Press after entering value to calculate square.	Press before entering value to calculate square root.	Enters character r.
$\sqrt[x]{\ }$ θ ^	Press between two values to make second value exponent of first.	Press between entering values for X & Y to show xth root of y.	Enters character θ .
QUIT EXIT	Backsteps to the previous menu.	Returns directly to initial screen of the mode.	
▲	Moves cursor upward. Scrolls screen.	Switches to previous function in trace mode.	
▼	Moves cursor downward. Scrolls screen.	Switches to next function in trace mode.	
◀	Moves cursor to left. Scrolls screen. Press after EXE to display calculation from end.		

Key Index

Key	Primary Function	combined with SHIFT	combined with ALPHA
▶	Moves cursor to right. Scrolls screen. Press after EXE to display calculation from beginning.		
A X,θ,T	Allows input of variable X, θ , and T.		Enters letter A.
10^x B log	Press before entering value to calculate common logalithm.	Press before entering exponent value of 10.	Enters letter B.
e^x C ln	Press before entering value to calculate natural logarithm.	Press before entering exponent value of e.	Enters letter C.
$\sin^{-1}$ D sin	Press before entering value to calculate sine.	Press before entering value to calculate inverse sine.	Enters letter D.
$\cos^{-1}$ E cos	Press before entering value to calculate cosine.	Press before entering value to calculate inverse cosine.	Enters letter E.
$\tan^{-1}$ F tan	Press before entering value to calculate tangent.	Press before entering value to calculate inverse tangent.	Enters letter F.
d/c G $a\frac{b}{c}$	Press between entering fraction values. Converts fraction to decimal.	Displays improper fractions.	Enters letter G.
H F↔D	Converts a fraction to a decimal value or a decimal value to a fraction. Sends a shot of the current screen to a connected device.		Enters letter H.
$\sqrt[3]{}$ I (	Enters open parenthesis in formula.	Press before entering value to calculate cube root.	Enters letter I.
x^{-1} J)	Enters close parenthesis in formula.	Press after entering value to calculate reciprocal.	Enters letter J.
K ,	Enters comma.		Enters letter K.
L →	Assigns value to a value memory name.		Enters letter L.
M 7	Enters number 7.		Enters letter M.
N 8	Enters number 8.		Enters letter N.
O 9	Enters number 9.		Enters letter O.

Key Index

Key	Primary Function	combined with SHIFT	combined with ALPHA
INS DEL	Deletes character at current cursor location.	Allows insertion of characters at cursor location.	
OFF AC/ON	Turns power on. Clears the display.	Turns power off.	
P 4	Enters number 4.		Enters letter P.
Q 5	Enters number 5.		Enters letter Q.
R 6	Enters number 6.		Enters letter R.
{ S ×	Multiplication function.	Enters open curly bracket.	Enters letter S.
} T ÷	Division function.	Enters close curly bracket.	Enters letter T.
U 1	Enters number 1.		Enters letter U.
V 2	Enters number 2.		Enters letter V.
W 3	Enters number 3.		Enters letter W.
[X +	Addition function. Specifies positive value.	Enters open bracket.	Enters letter X.
] Y −	Subtraction function. Specifies negative value.	Enters close bracket.	Enters letter Y.
Z 0	Enters number 0.		Enters letter Z.
= SPACE •	Enters decimal point.	Enters character =.	Enters a blank space.
π EXP	Allows entry of exponent.	Inputs value of pi. Enters pi symbol.	
Ans (−)	Enter before value to specify as negative.	Recalls most recent calculation result.	
↵ EXE	Displays result of calculation.	Inputs a new line.	