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ALGEBRA FX 2.0 PLUS
FX 1.0 PLUS

User's Guide

CASIO Worldwide Education Website

http://edu.casio.com

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CASIO®

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

NOTICE

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

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

FCC WARNING

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

Connector SB-62	Power Graphic Unit to Power Graphic Unit
Connector FA-123	Power Graphic Unit to PC for IBM/Macintosh Machine

Declaration of Conformity

Model Number:	ALGEBRA FX 2.0 PLUS / FX 1.0 PLUS
Trade Name:	CASIO COMPUTER CO., LTD.
Responsible party:	CASIO AMERICA, INC.
Address:	570 MT. PLEASANT AVENUE, DOVER, NEW JERSEY 07801
Telephone number:	973-361-5400

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

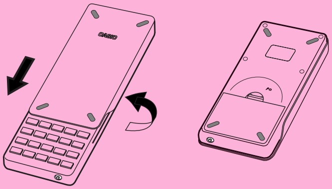
FOR CALIFORNIA USA ONLY

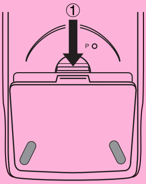
Perchlorate Material – special handling may apply. See
www.dtsc.ca.gov/hazardouswaste/perchlorate.

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.

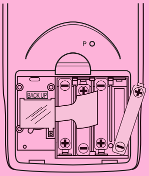
1. Making sure that you do not accidently press the AC/ON key, slide the case onto the calculator and then turn the calculator over. Remove the back cover from the calculator by pulling with your finger at the point marked ①.



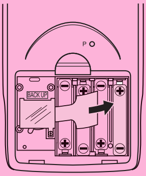


2. Load the four batteries that come with calculator.

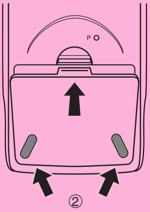
- Make sure that the positive (+) and negative (–) ends of the batteries are facing correctly.



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



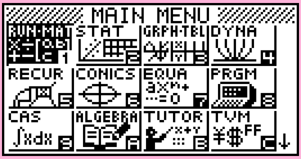
4. Replace the back cover, making sure that its tabs enter the holes marked ② and turn the calculator front side up. The calculator should automatically turn on power and perform the memory reset operation.



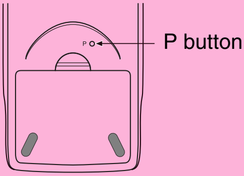
```
MAIN MEMORIES
          CLEARED!

Press [MENU] KEY
```

5. Press MENU.

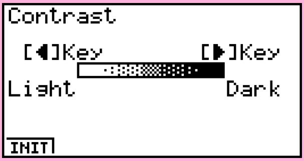
- If the Main Menu shown to the right is not on the display, press the P button on the back of the calculator to perform memory reset.



* The above shows the ALGEBRA FX 2.0 PLUS screen.



6. Use the cursor keys (▲, ▼, ◀, ▶) to select the **SYSTEM** icon and press EXE, then press F2 (▶) to display the contrast adjustment screen.



7. Adjust the contrast.

- The ▶ cursor key makes display contrast darker.
- The ◀ cursor key makes display contrast lighter.
- F1 (INIT) returns display contrast to its initial default.

8. To exit display contrast adjustment, press MENU.

Quick-Start

Quick-Start

Welcome to the world of graphing calculators.

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

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

Press 5 7

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

TURNING POWER ON AND OFF

To turn power on, press AC/ON .

To turn power off, press SHIFT $\overset{\text{OFF}}{\text{AC/ON}}$.

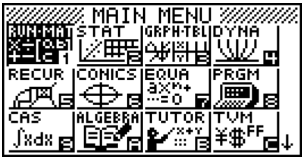
Calculator power turns off automatically if you do not perform any operation within the Auto Power Off trigger time you specify. You can specify either six minutes or 60 minutes as the trigger time.

USING MODES

This calculator 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 • MAT Mode

1. Press MENU to display the Main Menu.



* The above shows the ALGEBRA FX 2.0 PLUS screen.

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

   This is the initial screen of the RUN • MAT Mode, where you can perform manual calculations, matrix calculations, and run programs.

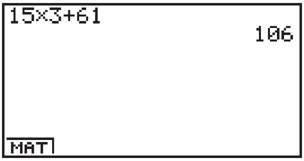
BASIC CALCULATIONS

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.

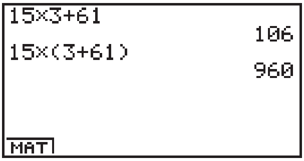


```
15×3+61
                 106
```

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

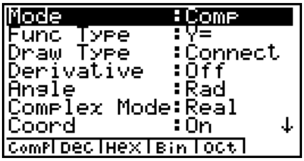
This calculator includes a number of built-in scientific functions, including trigonometric and logarithmic functions.

Example: 25 × sin 45˚

Important!

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

1. Press CTRL $\overset{\text{SET UP}}{\text{F3}}$ to display the SET UP screen.



```
Mode         :Comp
Func Type    :Y=
Draw Type    :Connect
Derivative   :Off
Angle        :Rad
Complex Mode:Real
Coord        :On      ↓
Comp DEC HEX Bin Oct
```

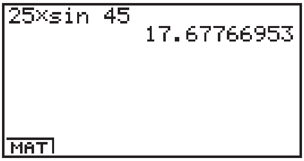
2. Press ▼ ▼ ▼ ▼ F1 (Deg) to specify degrees as the angle unit.

```
Angle        :Deg
```

3. Press ESC to clear the menu.

4. Press AC/ON to clear the unit.

5. Press 2 5 × sin 4 5 EXE .



```
25×sin 45
            17.67766953



MAT
```

REPLAY FEATURE

With the replay feature, simply press ◀ or ▶ to recall the last calculation that was performed 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˚)

---

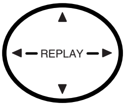
1. Press ◀ to display the last calculation.

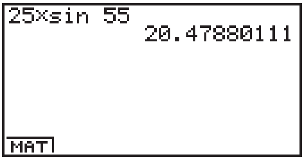
2. Press ◀ twice to move the cursor (⌷) to 4.

3. Press DEL to delete 4.

4. Press 5 .

5. Press EXE to execute the calculation again.





```
25×sin 55
            20.47880111



MAT
```

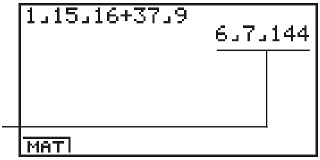
FRACTION CALCULATIONS

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 .



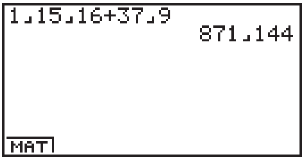
```
1⌟15⌟16+37⌟9
          6⌟7⌟144
MAT
```

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

Converting a Mixed Fraction to an Improper Fraction

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

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

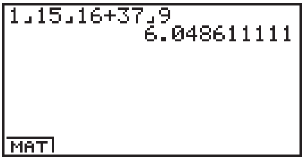


```
1⌟15⌟16+37⌟9
          871⌟144
MAT
```

Converting a Fraction to Its Decimal Equivalent

While a fraction is shown on the display, press a b/c to convert it to its decimal equivalent.

Press a b/c again to convert back to a fraction.



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

EXPONENTS

Example: 1250×2.06^5

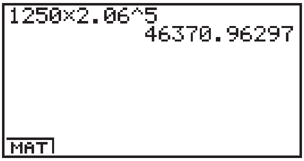
1. Press AC/ON .

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
```

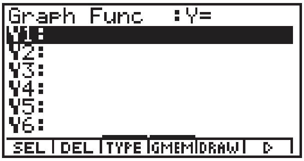
GRAPH FUNCTIONS

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).
All of the following graphing examples are performed starting from the calculator setup in effect immediately following a reset operation.

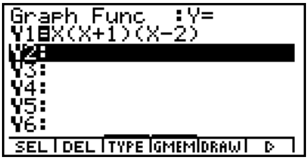
***Example* 1:** To graph Y = X(X + 1)(X – 2)

1. Press MENU .

2. Use ◀ ▶ ▲ ▼ to highlight **GRPH • TBL**, and then press EXE .

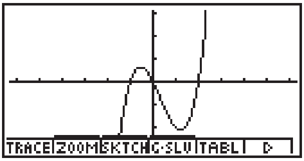


3. Input the formula.
   X,θ,T (X,θ,T + 1)
   (X,θ,T − 2) EXE



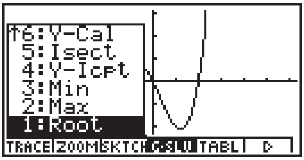
Y1=X(X+1)(X−2)

4. Press F5 (DRAW) or EXE to draw the graph.



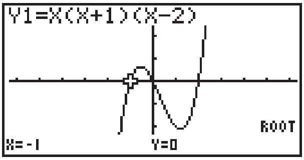
***Example* 2:** To determine the roots of Y = X(X + 1)(X – 2)

1. Press F4 (G-SLV) to display the pull-up menu.



2. Press 1 (Root).

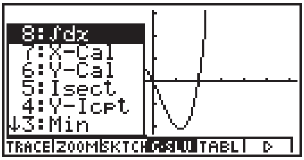
   Press ▶ for other roots.



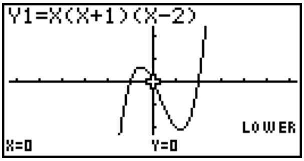
***Example* 3:** Determine the area bounded by the origin and the X = –1 root obtained for Y = X(X + 1)(X – 2)

---

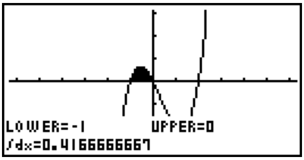
1. Press ESC F4 (G-SLV) ▼ .



2. Press 8 ($\int dx$).



3. Use ◀ to move the pointer to the location where X = –1, and then press EXE . Next, use ▶ 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.



```
LOWER=-1        UPPER=0
∫dx=0.4166666667
```

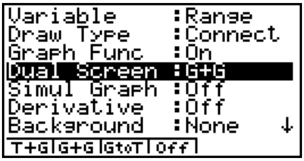
DUAL GRAPH

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

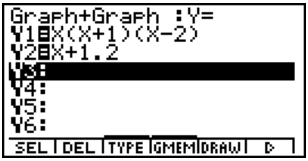
Y1 = X(X + 1)(X – 2)
Y2 = X + 1.2

1. Press **CTRL** **F3** (SET UP) ▼ ▼ ▼ **F2** (G+G)
   to specify “G+G” for the Dual Screen setting.



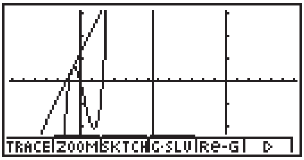
```
Variable      :Range
Draw Type     :Connect
Graph Func    :On
Dual Screen   :G+G
Simul Graph   :Off
Derivative    :Off
Background    :None    ↓
T+G|G+G|GtoT|Off
```

2. Press **ESC**, 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+Graph :Y=
Y1■X(X+1)(X-2)
Y2■X+1.2
Y3:
Y4:
Y5:
Y6:
SEL|DEL|TYPE|GMEM|DRAW| ▷
```

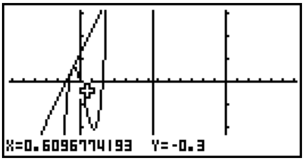
3. Press **F5** (DRAW) or **EXE** to draw the graphs.



BOX ZOOM

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

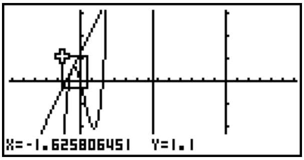
1. Press **F2** (ZOOM) **1** (Box).



```
X=0.6096774193   Y=-0.3
```

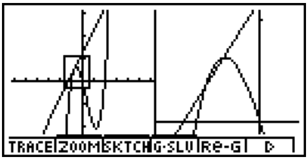
2. Use ◀ ▶ ▲ ▼ to move the pointer to one corner of the area you want to specify and then press **EXE**.

3. Use ◀ ▶ ▲ ▼ 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=-1.625806451 Y=1.1

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



DYNAMIC GRAPH

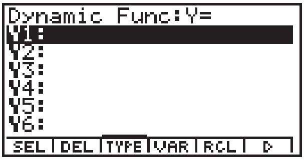
Dynamic Graph lets you see how the shape of a graph is affected as the value assigned to one of the coefficients of its function changes.

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.

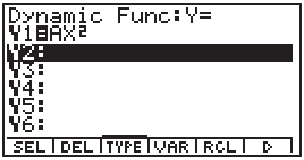
2. Use ◀ ▶ ▲ ▼ to highlight **DYNA**, and then press EXE.



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

3. Input the formula.

ALPHA $\overset{\text{A}}{\text{X,θ,T}}$ X,θ,T x^2 EXE

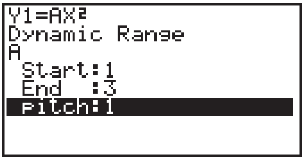


Dynamic Func:Y=
Y1■AX²
Y2:
Y3:
Y4:
Y5:
Y6:

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

Y1=AX²
Dynamic Var :A
A=1

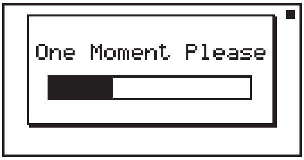
5. Press **F2** (RANG) **1** **EXE** **3** **EXE** **1** **EXE** to specify the range and increment of change in coefficient A.



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

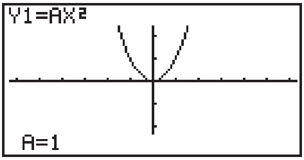
6. Press **ESC**.

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

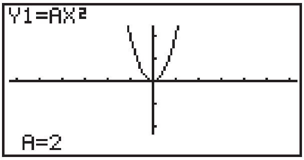


One Moment Please

↓



↓↑



↓↑

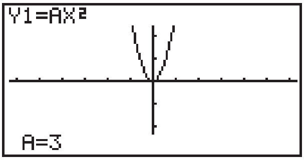


TABLE FUNCTION

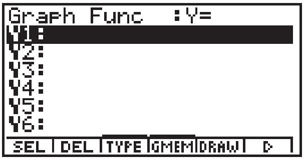
The Table Function makes it possible to generate a table of solutions as different values are assigned to the variables of a function.

Example: To create a number table for the following function

Y = X (X+1) (X–2)

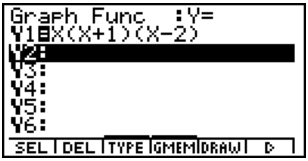
1. Press MENU .

2. Use ◀ ▶ ▲ ▼ to highlight **GRPH • TBL**, and then press EXE .



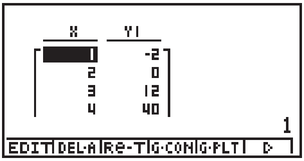
Graph Func :Y=
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:

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:

4. Press F6 (▷) F5 (TABL) to generate the number table.



X	Y1
1	-2
2	0
3	12
4	40

1

To learn all about the many powerful features of this calculator, 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 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 moistened with a solution of water and a neutral detergent and wrung out.
- Always be gentle when wiping dust off the display to avoid scratching it.
- In no event will the manufacturer and its suppliers be liable to you or any other person for any damages, expenses, lost profits, lost savings or any other damages arising out of loss of data and/or formulas arising out of malfunction, repairs, or battery replacement. It is up to you to 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 Main Batteries!” message or the “Low Backup Battery!” message appears on the display, replace the main power supply batteries or the back up battery as soon as possible.
- Be sure that the power switch is set to OFF when replacing batteries.
- If the calculator is exposed to a strong electrostatic charge, its memory contents may be damaged or the keys may stop working. In such a case, perform the Reset operation to clear the memory and restore normal key operation.
- If the calculator stops operating correctly for some reason, use a thin, pointed object to press the P button on the back of the calculator. Note, however, that this clears all the data in calculator memory.
- Note that strong vibration or impact during program execution can cause execution to stop or can damage the calculator’s memory contents.
- Using the calculator near a television or radio can cause interference with TV or radio reception.
- Before assuming malfunction of the unit, be sure to carefully reread this user’s guide and ensure that the problem is not due to insufficient battery power, programming or operational errors.

Be sure to keep physical records of all important data!

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. It is up to you to keep back up copies of data to protect against its loss.

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- The contents of this user's guide are subject to change without notice.
- No part of this user's guide may be reproduced in any form without the express written consent of the manufacturer.
- The options described in Chapter 10 of this user's guide may not be available in certain geographic areas. For full details on availability in your area, contact your nearest CASIO dealer or distributor.

ALGEBRA FX 2.0 PLUS
FX 1.0 PLUS

Contents

Getting Acquainted — Read This First!

Chapter 1 Basic Operation

Chapter 2 Manual Calculations

Chapter 3 List Function

Chapter 4 Equation Calculations

Chapter 5 Graphing

Chapter 6 Statistical Graphs and Calculations

Chapter 7 Computer Algebra System and Tutorial Modes (ALGEBRA FX 2.0 PLUS only)

Chapter 8 Programming

Chapter 9 System Settings Menu

Chapter 10 Data Communications

Appendix

Additional Functions

Getting Acquainted
— Read This First!

About this User's Guide

- SHIFT x^2 ($\sqrt{\ }$)

The above indicates you should press SHIFT and then x^2, which will input a $\sqrt{\ }$ symbol. All multiple-key input operations are indicated like this. Key cap markings are shown, followed by the input character or command in parentheses.

•Function Keys and Menus

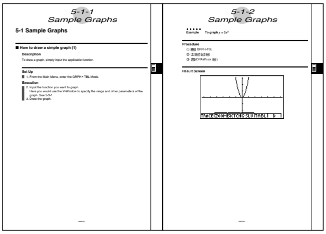
- Many of the operations performed by this calculator can be executed by pressing function keys F1 through F6. The operation assigned to each function key changes according to the mode the calculator is in, and current operation assignments are indicated by function menus that appear at the bottom of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

•Menu Titles

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

•Graphs

As a general rule, graph operations are shown on facing pages, with actual graph examples on the right hand page. You can produce the same graph on your calculator by performing the steps under the Procedure above the graph.
Look for the type of graph you want on the right hand page, and then go to the page indicated for that graph.
The steps under "Procedure" always use initial RESET settings.



5-1-1
Sample Graphs

5-1 Sample Graphs

■ How to draw a simple graph (1)

Description

To draw a graph, simply input the applicable function.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Input the function you want to graph.
Here you would use the V-Window to specify the range and other parameters of the graph. See 5-3-1.
3. Draw the graph.

5-1-2
Sample Graphs

Example To graph $y = 3x^2$

Procedure

① GRPH-TBL
②
③ (DRAW) (or)

Result Screen

The step numbers in the "SET UP" and "Execution" sections on the left hand page correspond to the "Procedure" step numbers on the right hand page.

Example:

Left hand page	Right hand page
3. Draw the graph.	③ F5 (DRAW)(or EXE)

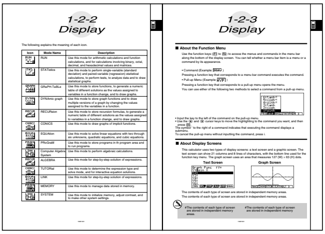
•Command List

The Program Mode Command List (page 8-7) provides a graphic flowchart of the various function key menus and shows how to maneuver to the menu of commands you need.

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

•Page Contents

Three-part page numbers are centered at the top of each page. The page number "1-2-3", for example, indicates Chapter 1, Section 2, page 3.



1-2-2
Display

The following explains the meaning of each icon.

Icon	Mode Name	Description
RUN	RUN	Use this mode for arithmetic calculations and function calculations, and for calculations involving binary, octal, decimal, and hexadecimal values and matrices.
STAT	STATistics	Use this mode to perform single-variable (standard deviation) and paired-variable (regression) statistical calculations, to perform tests, to analyze data and to draw statistical graphs.
GRAPH	GRaPH-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.
DYNA	DYNAmic graph	Use this mode to store graph functions and to draw multiple versions of a graph by changing the values assigned to the variables in a function.
RECUR	RECURsion	Use this mode to store recursion formulas, to generate a numeric table of different solutions as the values assigned to variables in a function change, and to draw graphs.
CONICS	CONICS	Use this mode to draw graphs of implicit functions.
EQUA	EQUAtion	Use this mode to solve linear equations with two through six unknowns, quadratic equations, and cubic equations.
PRGM	PRoGraM	Use this mode to store programs in th program area and to run programs.
LINK	Computer Algebra System	Use this mode to perform algebraic calculations.
RECUR	ALGEBRA	Use this mode for step-by-step solution of expressions.
CONICS	TUTORial	Use this mode to determine the expression type and solve mode, and for interactive equation solutions.
EQUA	LINK	Use this mode for step-by-step solution of expressions.
PRGM	MEMORY	Use this mode to manage data stored in memory.
LINK	SYSTEM	Use this mode to initialize memory, adjust contrast, and to make other system settings.

1-2-3
Display

■ About the Function Menu

Use the function keys (F1 to F6) to access the menus and commands in the menu bar along the bottom of the display screen. You can tell whether a menu bar item is a menu or a command by its appearance.

• Command (Example: DRAW)
Pressing a function key that corresponds to a menu bar command executes the command.
• Pull-up Menu (Example: HYP)
Pressing a function key that corresponds to a pull-up menu opens the menu.
You can use either of the following two methods to select a command from a pull-up menu.

• Input the key to the left of the command on the pull-up menu.
• Use the ▲ and ▼ cursor keys to move the highlighting to the command you want, and then press EXE.
The symbol ' to the right of a command indicates that executing the command displays a submenu.
To cancel the pull-up menu without inputting the command, press i.

■ About Display Screens

This calculator uses two types of display screens: a text screen and a graphic screen. The text screen can show 21 columns and 8 lines of characters, with the bottom line used for the function key menu. The graph screen uses an area that measures 127 (W) × 63 (H) dots.

Text Screen
Graph Screen

The contents of each type of screen are stored in independent memory areas.
The contents of each type of screen are stored in independent memory areas.

#The contents of each type of screen are stored in independent memory areas.
#The contents of each type of screen are stored in independent memory areas.

•Supplementary Information

Supplementary information is shown at the bottom of each page in a "✎ (Notes)" block.

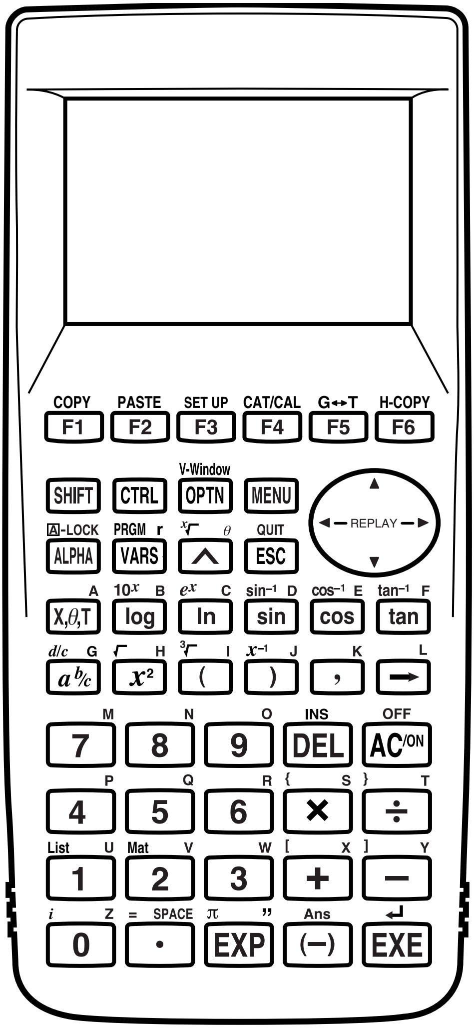
∗ indicates a note about a term that appears in the same page as the note.

\# indicates a note that provides general information about topic covered in the same section as the note.

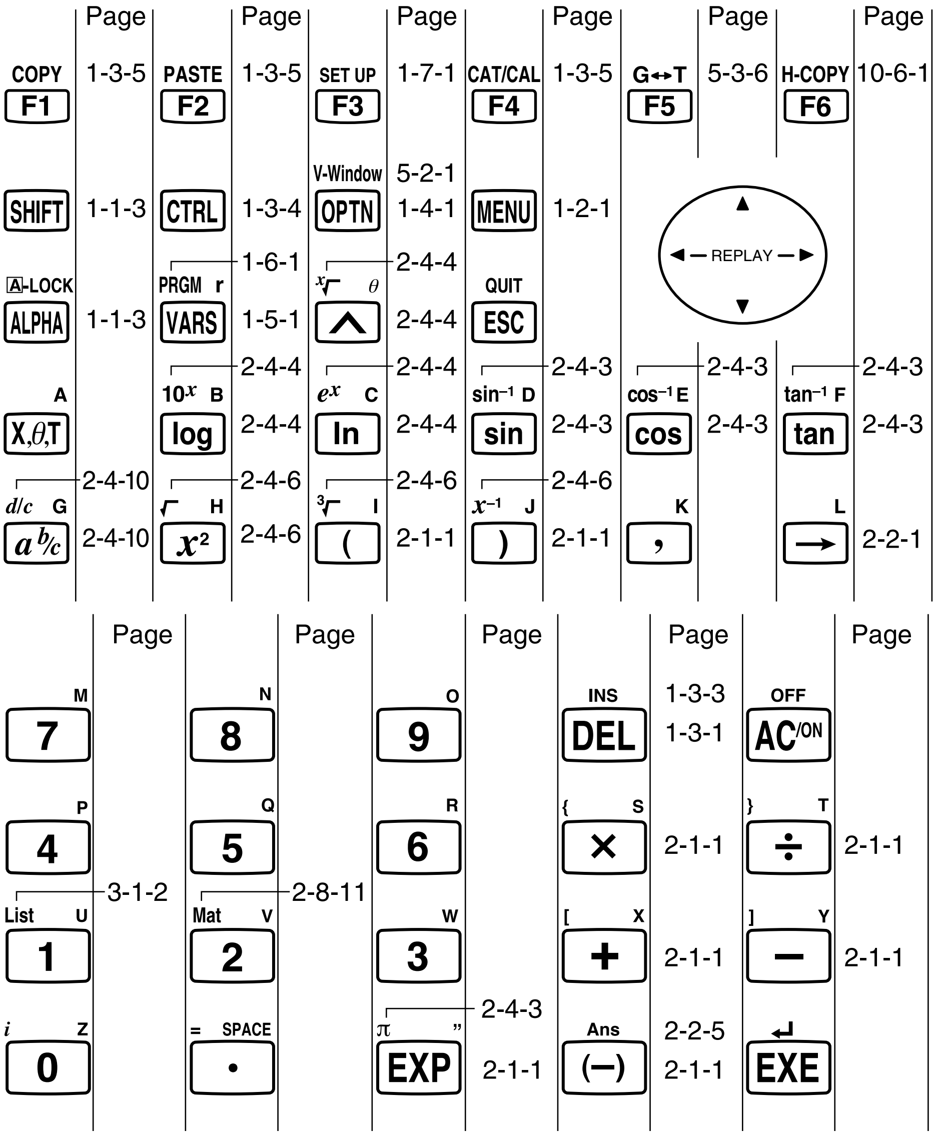
Chapter 1

Basic Operation

1-1 Keys

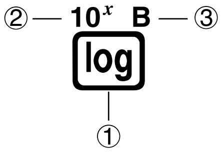

COPY
F1
PASTE
F2
SET UP
F3
CAT/CAL
F4
G↔T
F5
H-COPY
F6
V-Window
SHIFT
CTRL
OPTN
MENU
REPLAY
A-LOCK
ALPHA
PRGM
r
VARS
θ
QUIT
ESC
A
X,θ,T
10x
B
log
ex
C
ln
sin⁻¹
D
sin
cos⁻¹
E
cos
tan⁻¹
F
tan
d/c
G
ab/c
H
x²
I
(
x⁻¹
J
)
K
,
L
→
M
7
N
8
O
9
INS
DEL
OFF
AC/ON
P
4
Q
5
R
6
{
S
×
}
T
÷
List
U
1
Mat
V
2
W
3
[
X
+
]
Y
−
i
Z
0
=
SPACE
•
π
”
EXP
Ans
(−)
EXE

■ Key Table


Page
Page
Page
Page
Page
Page
COPY F1 1-3-5
PASTE F2 1-3-5
SET UP F3 1-7-1
CAT/CAL F4 1-3-5
G↔T F5 5-3-6
H-COPY F6 10-6-1
V-Window 5-2-1
SHIFT 1-1-3
CTRL 1-3-4
OPTN 1-4-1
MENU 1-2-1
REPLAY
1-6-1
2-4-4
A-LOCK
PRGM r
x√ θ
QUIT
ALPHA 1-1-3
VARS 1-5-1
^ 2-4-4
ESC
2-4-4
2-4-4
2-4-3
2-4-3
2-4-3
A
10^x B
e^x C
sin⁻¹ D
cos⁻¹ E
tan⁻¹ F
X,θ,T
log 2-4-4
ln 2-4-4
sin 2-4-3
cos 2-4-3
tan 2-4-3
2-4-10
2-4-6
2-4-6
2-4-6
d/c G
√ H
∛ I
x⁻¹ J
K
L
a b/c 2-4-10
x² 2-4-6
(2-1-1
) 2-1-1
,
→ 2-2-1
Page
Page
Page
Page
Page
M 7
N 8
O 9
INS DEL 1-3-3 1-3-1
OFF AC/ON
P 4
Q 5
R 6
{ S × 2-1-1
} T ÷ 2-1-1
3-1-2
2-8-11
List U 1
Mat V 2
W 3
[X + 2-1-1
] Y − 2-1-1
2-4-3
i Z 0
= SPACE .
π ” EXP 2-1-1
Ans (−) 2-2-5 2-1-1
↵ EXE

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.

A-LOCK
ALPHA **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.

1-2 Display

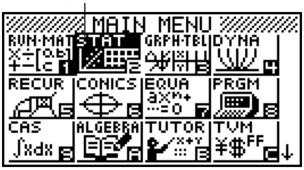
Selecting Icons

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

•To select an icon

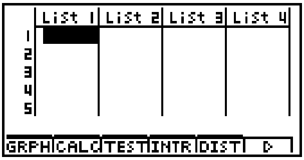
1. Press MENU to display the Main Menu.
2. Use the cursor keys (◀, ▶, ▲, ▼) to move the highlighting to the icon you want.

Currently selected icon



* The above shows the ALGEBRA FX 2.0 PLUS screen.

3. Press EXE to display the initial screen of the mode whose icon you selected. Here we will enter the STAT Mode.



- 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.

The following explains the meaning of each icon.

Icon	Mode Name	Description
RUN·MAT 1	RUN • MATrix	Use this mode for arithmetic calculations and function calculations, and for calculations involving binary, octal, decimal, and hexadecimal values and matrices.
STAT 2	STATistics	Use this mode to perform single-variable (standard deviation) and paired-variable (regression) statistical calculations, to analyze data and to draw statistical graphs.

Icon	Mode Name	Description
GRPH·TBL 3	GRaPH-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.
DYNA 4	DYNAmic graph	Use this mode to store graph functions and to draw multiple versions of a graph by changing the values assigned to the variables in a function.
RECUR 5	RECURsion	Use this mode to store recursion formulas, to generate a numeric table of different solutions as the values assigned to variables in a function change, and to draw graphs.
CONICS 6	CONICS	Use this mode to draw graphs of conic sections.
EQUA 7	EQUAtion	Use this mode to solve linear equations with 2 to 30 unknowns, and higmh degree (2 to 30) equations.
PRGM 8	PRoGraM	Use this mode to store programs in th program area and to run programs.
CAS ∫xdx 9	Computer Algebra System	Use this mode to perform algebraic calculations. (ALGEBRA FX 2.0 PLUS only)
ALGEBRA A	ALGEBRA	Use this mode for step-by-step solution of expressions. (ALGEBRA FX 2.0 PLUS only)
TUTOR B	TUTORial	Use this mode to determine the expression type and solve mode, and for interactive equation solutions. (ALGEBRA FX 2.0 PLUS only)
TVM ¥$FF C	TVM (Financial)	Use this mode to perform financial calculations. (On the FX 1.0 PLUS menu, the icon has the number 9 in the lower right corner.)
DIFF EQ dY/dX= D	DIFFerential EQuation	Use this mode to solve differential equations. (On the FX 1.0 PLUS menu, the icon has the letter A in the lower right corner.)
E·CON E	E-CON	Use this mode when you want to control a CASIO EA-100 unit from this calculator. (On the FX 1.0 PLUS menu, the icon has the letter B in the lower right corner.)
LINK F	LINK	Use this mode to transfer memory contents or back-up data to another unit. (On the FX 1.0 PLUS menu, the icon has the letter C in the lower right corner.)
MEMORY G	MEMORY	Use this mode to manage data stored in memory. (On the FX 1.0 PLUS menu, the icon has the letter D in the lower right corner.)
SYSTEM H	SYSTEM	Use this mode to initialize memory, adjust contrast, and to make other system settings. (On the FX 1.0 PLUS menu, the icon has the letter E in the lower right corner.)

About the Function Menu

Use the function keys (F1 to F6) to access the menus and commands in the menu bar along the bottom of the display screen. You can tell whether a menu bar item is a menu or a command by its appearance.

- **Command** (Example: DRAW)

Pressing a function key that corresponds to a menu bar command executes the command.

- **Pull-up Menu** (Example: HYP)

Pressing a function key that corresponds to a pull-up menu opens the menu.

You can use either of the following two methods to select a command from a pull-up menu.

```
6:tanh⁻¹
5:cosh⁻¹
4:sinh⁻¹
3:tanh
2:cosh
1:sinh
PROB HYP ANGL STAT FMEM ▷
```

- Input the key to the left of the command on the pull-up menu.
- Use the ▲ and ▼ cursor keys to move the highlighting to the command you want, and then press EXE.

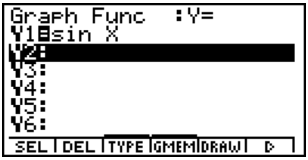
The symbol ► to the right of a command indicates that executing the command displays a submenu.

To cancel the pull-up menu without inputting the command, press ESC.

About Display Screens

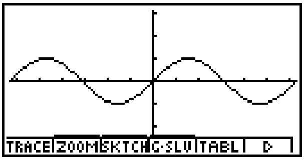
This calculator uses two types of display screens: a text screen and a graphic screen. The text screen can show 21 columns and 8 lines of characters, with the bottom line used for the function key menu. The graph screen uses an area that measures 127 (W) × 63 (H) dots.

Text Screen



```
Graph Func   :Y=
Y1■sin X
Y2:
Y3:
Y4:
Y5:
Y6:
SEL DEL TYPE GMEM DRAW ▷
```

Graph Screen



The contents of each type of screen are stored in independent memory areas.

Press CTRL F5 (G↔T) to switch between the graphic screen and text screen.

The symbol ↑ in the upper left corner of a pull-up menu indicates that there are more commands running off the top of the menu. Use the cursor keys to scroll the menu contents to view the commands running off the top.

Normal 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.

• 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.

You can specify one of two different ranges for automatic changeover to normal display.

Norm 1 .... 10^{-2} (0.01) > $|x|$, $|x| \geqq 10^{10}$
Norm 2 .... 10^{-9} (0.000000001) > $|x|$, $|x| \geqq 10^{10}$

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

See page 2-3-2 for details on switching between Norm 1 and Norm 2.

■ Special Display Formats

This calculator uses special display formats to indicate fractions, hexadecimal values, and degrees/minutes/seconds values.

- Fractions

```
456⌟12⌟23
          456⌟12⌟23
```

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

- Hexadecimal Values

```
ABCDEF12
            ABCDEF12
```

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

- Degrees/Minutes/Seconds

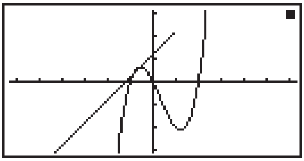
```
12.58244
       12°34’56.78”
```

.... Indicates: 12° 34’ 56.78”

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

■ Calculation Execution Indicator

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



1-3 Inputting and Editing Calculations

■ Inputting Calculations

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

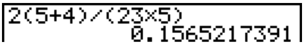
● ● ● ● ●
Example 1 **2 + 3 – 4 + 10 =**

AC 2 + 3 − 4 + 1 0 EXE

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

● ● ● ● ●
Example 2 **2(5 + 4) ÷ (23 × 5) =**

AC 2 (5 + 4) ÷
(2 3 × 5) EXE



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

■ 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 you can use ▶ to move to the end of the calculation and input more.

• To change a step

● ● ● ● ●
Example **To change cos60 to sin60**

AC cos 6 0

```
cos 60
```

◀ ◀ ◀

```
cos 60
```

DEL

```
60
```

sin

```
sin 60
```

• To delete a step

• • • • •

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

AC 3 6 9 × × 2


369××2

◀ ◀ DEL


369×2

• To insert a step

• • • • •

Example **To change 2.36^2 to sin2.36^2**

AC 2 • 3 6 x^2


2.36²

◀ ◀ ◀ ◀ ◀


2.36²

sin


sin 2.36²

• To change the last step you input

• • • • •

Example **To change 396 × 3 to 396 × 2**

AC 3 6 9 × 3


369×3

DEL


369×

2


369×2

■ Using Replay Memory

The last calculation performed is always stored 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 1 **To perform the following two calculations**
4.12 × <u>6.4</u> = 26.368
4.12 × <u>7.1</u> = 29.252

AC 4 • 1 2 × 6 • 4 EXE

```
4.12×6.4
                 26.368
```

◀ ◀ ◀ ◀

```
4.12×6.4
```

SHIFT DEL (INS)

```
4.12×6.4
```

7 • 1

```
4.12×7.1_
```

EXE

```
4.12×7.1
                 29.252
```

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.

● ● ● ● ●

Example 2

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

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

AC

▲ (One calculation back)

```
234-567
```

▲ (Two calculations back)

```
123+456
```

Pressing SHIFT DEL (INS) changes the cursor to "_". The next function or value you input is overwritten at the location of "_". To abort this operation, press SHIFT DEL (INS) again.

A calculation remains stored in replay memory until you perform another calculation or change modes.

The contents of 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.

■ 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


14/0×2.3

EXE


Ma ERROR
Press:[ESC]

Press ESC.


14/0×2.3

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

Make necessary changes.

◀ 1


14/10×2.3

Execute again.

EXE

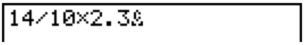

14/10×2.3
3.22

■ Copy and Paste

You can temporarily copy commands, programs, and other text data you input to a memory area called “the clipboard,” and then paste it to another location on the display.

• To specify the copy range

1. Move the cursor (⌷) the beginning or end of the range of text you want to copy and then press CTRL. This changes the cursor to “⌷”.


14/10×2.3

2. Use the cursor keys to move the cursor and highlight the range of text you want to copy.


14/10×2.3

3. Press CTRL F1 (COPY) to copy the highlighted text to the clipboard, and exit the copy range specification mode.

14/10×2.3

To cancel text highlighting without performing a copy operation, press ESC.

• Pasting Text

Move the cursor to the location where you want to paste the text, and then press CTRL F2 (PASTE). The contents of the clipboard are pasted at the cursor position.

AC

CTRL F2 (PASTE)

14/10×2.3

■ Catalog Function

The Catalog is an alphabetic list of all the commands available on this calculator. You can input a command by calling up the Catalog and then selecting the command you want.

• To use the Catalog to input a command

1. Press CTRL F4 (CAT/CAL) to display the Catalog at the bottom of the screen.

2. Press the function key that matches the first letter of the command you want to input.
3. Select the command from the pull-up menu.

● ● ● ● ●

Example 1 To use the Catalog to input the ClrGraph command

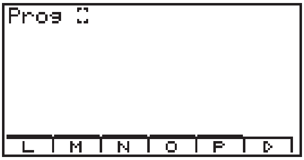
AC CTRL F4 (CAT/CAL) F3 (C~) 7 (CLR)
1 (Graph)

ClrGraph

● ● ● ● ●

Example 2 To use the Catalog to input the Prog command

AC CTRL F4(CAT/CAL) F6(▷) F6(▷)
F5(P) ln(Prog)


Prog ⁚⁚

Pressing ESC or SHIFT ESC(QUIT) closes the Catalog.

1-4 Option (OPTN) Menu

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

See "8-7 Program Mode Command List" for details on the option (OPTN) menu.

• Option Menu in the RUN • MAT or PRGM Mode

- {**LIST**} ... {list function menu}
- {**MAT**} ... {matrix operation menu}
- {**CPLX**} ... {complex number calculation menu}
- {**CALC**} ... {functional analysis menu}
- {**NUM**} ... {numeric calculation menu}
- {**PROB**} ... {probability/distribution calculation menu}
- {**HYP**} ... {hyperbolic calculation menu}
- {**ANGL**} ... {menu for angle/coordinate conversion, DMS input/conversion}
- {**STAT**} ... {paired-variable statistical estimated value menu}
- {**FMEM**} ... {function memory menu}
- {**ZOOM**} ... {zoom function menu}
- {**SKTCH**} ... {sketch function menu}
- {**PICT**} ... {picture memory menu}
- {**SYBL**} ... {symbol menu}
- {**° ' "**} … {DMS}
- {**↼ ° ' "**} … {DMS conversion}
- {**ENG**}/{**↼ ENG**} … {ENG conversion}

The option (OPTN) menu does not appear during binary, octal, decimal, and hexadecimal calculations.

The following shows the function menus that appear under other conditions.

• Option Menu when a number table value is displayed in the GRPH • TBL or RECUR Mode

- {**LMEM**} … {list memory menu}
- {↼° ’ ”}/{**ENG**}/{↼ **ENG**}

• Option Menu in the CAS or ALGEBRA or TUTOR Mode (ALGEBRA FX 2.0 PLUS only)

- {∞} … {infinity}
- {**Abs**} … {absolute value}
- {***x*!**} … {factorial}
- {**sign**} … {signum function}
- {**HYP**}/{**FMEM**}

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

1-5 Variable Data (VARS) Menu

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

{**V-WIN**}/{**FACT**}/{**STAT**}/{**GRPH**}/{**DYNA**}/
{**TABL**}/{**RECR**}/{**EQUA**[*1]}

See “8-7 Program Mode Command List” for details on the variable data (VARS) menu.

• V-WIN — Recalling View Window values

- {**Xmin**}/{**Xmax**}/{**Xscale**}/{**Xdot**}
  …X-axis {minimum value}/{maximum value}/{scale}/{dot value[*2]}
- {**Ymin**}/{**Ymax**}/{**Yscale**}
  …Y-axis {minimum value}/{maximum value}/{scale}
- {**Tθmin**}/{**Tθmax**}/{**Tθptch**}
  …T, θ {minimum value}/{maximum value}/{pitch}
- {**R-Xmin**}/{**R-Xmax**}/{**R-Xscl**}/{**R-Xdot**}
  …Dual Graph right graph X-axis {minimum value}/{maximum value}/{scale}/{dot value[*2]}
- {**R-Ymin**}/{**R-Ymax**}/{**R-Yscl**}
  …Dual Graph right graph Y-axis {minimum value}/{maximum value}/{scale}
- {**R-Tmin**}/{**R-Tmax**}/{**R-Tpch**}
  …Dual Graph right graph T,θ {minimum value}/{maximum value}/{pitch}

• FACT — Recalling zoom factors

- {**Xfact**}/{**Yfact**}
  ... {x-axis factor}/{y-axis factor}

[*1] The EQUA item appears only when you access the variable data menu from the RUN•MAT or PRGM Mode.

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

[*2] The dot value indicates the display range (Xmax value – Xmin value) divided by the screen dot pitch (126).
The dot value is normally calculated automatically from the minimum and maximum values. Changing the dot value causes the maximum to be calculated automatically.

• STAT — Recalling statistical data

- {**n**} … {number of data}
- {**X**} … {single-variable, paired-variable x-data}
  - {$\bar{x}$}/{Σx}/{Σx^2}/{$x\sigma n$}/{$x\sigma n{-}1$}/{**minX**}/{**maxX**}
    …{mean}/{sum}/{sum of squares}/{population standard deviation}/{sample standard deviation}/{minimum value}/{maximum value}
- {**Y**} ... {paired-variable y-data}
  - {$\bar{y}$}/{Σy}/{Σy^2}/{Σxy}/{$y\sigma n$}/{$y\sigma n{-}1$}/{**minY**}/{**maxY**}
    …{mean}/{sum}/{sum of squares}/{sum of products of x-data and y-data}/{population standard deviation}/{sample standard deviation}/{minimum value}/{maximum value}
- {**GRAPH**} ... {graph data menu}
  - {a}/{b}/{c}/{d}/{e}
    ... {regression coefficient and polynomial coefficients}
  - {r}/{r^2}
    ... {correlation coefficient}
  - {**Q1**}/{**Q3**}
    ... {first quartile}/{third quartile}
  - {**Med**}/{**Mod**}
    ... {median}/{mode} of input data
  - {**H-Strt**}/{**H-ptch**}
    ... histogram {start division}/{pitch}
- {**PTS**} ... {summary point data menu}
  - {x_1}/{y_1}/{x_2}/{y_2}/{x_3}/{y_3} ... {coordinates of summary points}

• GRPH — Recalling Graph Functions

- {**Y*n***}/{***rn***}
  ... {rectangular coordinate or inequality function}/{polar coordinate function}
- {**Xt*n***}/{**Yt*n***}
  ... parametric graph function {Xt}/{Yt}
- {**X*n***} ... {X=constant graph function}
  (Press these keys before inputting a value to specify a storage area.)

• DYNA — Recalling Dynamic Graph Set Up Data

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

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

- {**Start**}/{**End**}/{**Pitch**}
  ... {table range start value}/{table range end value}/{table value increment}
- {**Result**[*1]}
  ... {matrix of table contents}

[*1] The Result item appears only when the TABL menu is displayed in the RUN•MAT or PRGM Mode.

• RECR — Recalling Recursion Formula[*1], Table Range, and Table Content Data

- {**FORM**} ... {recursion formula data menu}
  - {a_n}/{a_{n+1}}/{a_{n+2}}/{b_n}/{b_{n+1}}/{b_{n+2}}/{c_n}/{c_{n+1}}/{c_{n+2}}
    ... {a_n}/{a_{n+1}}/{a_{n+2}}/{b_n}/{b_{n+1}}/{b_{n+2}}/{c_n}/{c_{n+1}}/{c_{n+2}} expressions
- {**RANGE**} ... {table range data menu}
  - {**R-Strt**}/{**R-End**}
    ... table range {start value}/{end value}
  - {a_0}/{a_1}/{a_2}/{b_0}/{b_1}/{b_2}/{c_0}/{c_1}/{c_2}
    ... {a_0}/{a_1}/{a_2} {b_0}/{b_1}/{b_2}/{c_0}/{c_1}/{c_2} value
  - {**a_nStrt**}/{**b_nStrt**}/{**c_nStrt**}
    ... origin of {a_n}/{b_n}/{c_n} recursion formula convergence/divergence graph (WEB graph)
- {**Result**[*2]} ... {matrix of table contents[*3]}

• EQUA — Recalling Equation Coefficients and Solutions[*4] [*5]

- {**S-Rslt**}/{**S-Coef**}
  ... matrix of {solutions}/{coefficients} for linear equations[*6]
- {**P-Rslt**}/{**P-Coef**}
  ... matrix of {solution}/{coefficients} for a high degree equation

[*1] An error occurs when there is no function or recursion formula numeric table in memory.

[*2] "Result" is available only in the RUN•MAT and PRGM Modes.

[*3] Table contents are stored automatically in Matrix Answer Memory (MatAns).

[*4] Coefficients and solutions are stored automatically in Matrix Answer Memory (MatAns).

[*5] The following conditions cause an error.
— When there are no coefficients input for the equation
— When there are no solutions obtained for the equation

[*6] Coefficient and solution memory data for a linear equation cannot be recalled at the same time.

1-6 Program (PRGM) Menu

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

- {**Prog**} .... {program recall}
- {**JUMP**} ...... {jump command menu}
- {**?**} .... {input prompt}
- {**◢**} .... {output command}
- {**I/O**} .... {I/O control/transfer command menu}
- {**IF**} .... {conditional jump command menu}
- {**FOR**} .... {loop control command menu}
- {**WHLE**} ...... {conditional loop control command menu}
- {**CTRL**} .... {program control command menu}
- {**LOGIC**} ..... {logical operation command menu}
- {**CLR**} .... {clear command menu}
- {**DISP**} .... {display command menu}
- {**:**} .... {multistatement connector}

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

- {**Prog**}/{**JUMP**}/{**?**}/{**◢**}/{**:**}
- {**= ≠ <**} .... {relational operator menu}

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

For details on the commands that are available in the various menus you can access from the program menu, see “8. Programming”.

1-7 Using the Set Up Screen

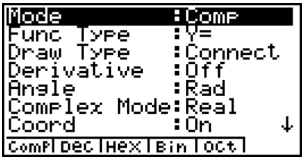
The mode's set up screen shows the current status of mode settings and lets you make any changes you want. The following procedure shows how to change a set up.

• To change a mode set up

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

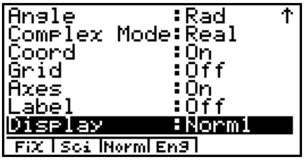
2. Press CTRL F3 (SET UP) to display the mode's SET UP screen.

- 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
Complex Mode:Real
Coord :On ↓

⋮



Angle :Rad ↑
Complex Mode:Real
Coord :On
Grid :Off
Axes :On
Label :Off
Display :Norm1

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 ESC 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.

〰 indicates default setting.

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

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

- **Func Type (graph function type)**

  Pressing one of the following function keys also switches the function of the X,θ,T key.

  - {**Y=**}/{**r=**}/{**Parm**}/{**X=c**}

    ... {rectangular coordinate}/{polar coordinate}/{parametric coordinate}/{X = constant} graph
  - {**Y>**}/{**Y<**}/{**Y≥**}/{**Y≤**}

    ... {$y>f(x)$}/{$y<f(x)$}/{$y \geq f(x)$}/{$y \leq f(x)$} inequality graph

- **Draw Type (graph drawing method)**
  - {**Con**}/{**Plot**}

    ... {connected points}/{unconnected points}

- **Derivative (derivative value display)**
  - {**On**}/{**Off**}

    ... {display on}/{display off} while Graph-to-Table, Table & Graph, and Trace are being used

- **Angle (default angle unit)**
  - {**Deg**}/{**Rad**}/{**Gra**}

    ... {degrees}/{radians}/{grads}

- **Complex Mode**
  - {**Real**} ... {calculation in real number range only}
  - {$a + bi$}/{$r \cdot e \wedge \theta i$}

    ... {rectangular format}/{polar format} display of a complex calculation

- **Coord (graph pointer coordinate display)**
  - {**On**}/{**Off**}

    ... {display on}/{display off}

- **Grid (graph gridline display)**
  - {**On**}/{**Off**}

    ... {display on}/{display off}

- **Axes (graph axis display)**
  - {**On**}/{**Off**}

    ... {display on}/{display off}

- **Label (graph axis label display)**
  - {**On**}/{**Off**}

    ... {display on}/{display off}

- **Display (display format)**
  - {**Fix**}/{**Sci**}/{**Norm**}/{**Eng**}

    ... {fixed number of decimal places specification}/{number of significant digits specification}/{normal display setting}/{Engineering Mode}

- **Stat Wind (statistical graph view window setting method)**
  - {**Auto**}/{**Man**}

    ... {automatic}/{manual}

- **Reside List (residual calculation)**
  - {**None**}/{**LIST**}

    ... {no calculation}/{list specification for the calculated residual data}

- **List File (list file display settings)**
  - {**FILE**} ... {settings of list file on the display}

- **Variable (table generation and graph draw settings)**
  - {**Rang**}/{**LIST**}

    ... {use table range}/{use list data}

- **Graph Func (function display during graph drawing and trace)**
  - {**On**}/{**Off**}

    ... {display on}/{display off}

- **Dual Screen (Dual Screen Mode status)**
  - {**T+G**}/{**G+G**}/{**GtoT**}/{**Off**}

    ... {graph on one side and numeric table on the other side of Dual Screen}/{graphing on both sides of Dual Screen}/{graph on one side and numeric table on the other side of Dual Screen}/{Dual Screen off}

- **Simul Graph (simultaneous graphing mode)**
  - {**On**}/{**Off**}

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

- **Background (graph display background)**
  - {**None**}/{**PICT**}

    ... {no background}/{graph background picture specification}

- **Dynamic Type (Dynamic Graph locus setting)**
  - {**Cnt**}/{**Stop**}
    ... {non-stop (continuous)}/{automatic stop after 10 draws}

- **Σ Display (Σ value display in recursion table)**
  - {**On**}/{**Off**}
    ... {display on}/{display off}

- **Slope (display of derivative at current pointer location in conic section graph)**
  - {**On**}/{**Off**}
    ... {display on}/{display off}

- **Answer Type (result range specification) (ALGEBRA FX 2.0 PLUS only)**
  - {**Real**}/{**Cplx**}
    ... {real number}/{complex number} range result

- **H-Copy (screen shot settings)**
  - {**Dirct**}/{**Mem**}
    ... {direct send}/{store in memory}

1-8 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.

■ Getting the Calculator Back to its Original Mode Settings

1. From the Main Menu, enter the SYSTEM Mode.
2. Press F5 (Reset).
3. Press F1 (S/U), and then press EXE (Yes).
4. Press MENU to return to the Main Menu.

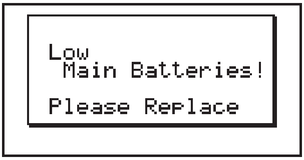
Now enter the correct mode and perform your calculation again, monitoring the results on the display.

■ In Case of Hang Up

- 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 calculator to its initial defaults (see page α-6-1). Note, however, that this may clear all the data in calculator memory.

Low Battery Message

If either of the following messages appears on the display, immediately turn off the calculator and replace main batteries or the back up battery as instructed.



```
Low
 Main Batteries!
Please Replace
```

```
Low
 Backup Battery!
Please Replace
```

If you continue using the calculator without replacing main 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 after the low battery message appears.

If main batteries and the back up battery go low at the same time (indicated when both of the messages described above appear), replace the back up battery first and then replace the main batteries.

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
$23 + 4.5 - 53 = -25.5$	**23 + 4.5 − 53 EXE**
$56 \times (-12) \div (-2.5) = 268.8$	**56 × (−) 12 ÷ (−) 2.5 EXE**
$(2 + 3) \times 10^2 = 500$	**(2 + 3) × 1 EXP 2 EXE** *1
$1 + 2 - \underline{3 \times 4 \div 5} + 6 = 6.6$	**1 + 2 − 3 × 4 ÷ 5 + 6 EXE**
$100 - (2 + 3) \times 4 = 80$	**100 − (2 + 3) × 4 EXE**
$2 + 3 \times (4 + 5) = 29$	**2 + 3 × (4 + 5 EXE** *2
$(7 - 2) \times (8 + 5) = 65$	**(7 − 2) (8 + 5) EXE** *3
$\frac{6}{4 \times 5} = 0.3$	**6 ÷ (4 × 5) EXE** *4
$(1 + 2i) + (2 + 3i) = 3 + 5i$	(1 + 2 SHIFT 0 (*i*)) + (2 + 3 SHIFT 0 (*i*)) EXE
$(2 + i) \times (2 - i) = 5$	(2 + SHIFT 0 (*i*)) × (2 − SHIFT 0 (*i*)) EXE

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

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

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

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

Number of Decimal Places, Number of Significant Digits, Normal Display Range

[SET UP]-[Display]-[Fix]/[Sci]/[Norm]

- 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 of the Numeric Calculation Menu (NUM) (page 2-4-1) to round the displayed value off to the number of decimal place and significant digit settings.
- Number of decimal place (Fix) and significant digit (Sci) settings normally remain in effect until you change them or until you change the normal display range (Norm) setting.

● ● ● ● ●

Example **100 ÷ 6 = 16.66666666...**

Condition	Operation	Display
	100 ÷ 6 EXE	**16.66666667**
4 decimal places	CTRL F3 (SET UP) ▼▼▼▼▼▼▼▼▼▼ F1 (Fix) 4 EXE ESC EXE	**16.6667**[1]
5 significant digits	CTRL F3 (SET UP) ▼▼▼▼▼▼▼▼▼▼ F2 (Sci) 5 EXE ESC EXE	**1.6667E+01**[1]
Cancels specification	CTRL F3 (SET UP) ▼▼▼▼▼▼▼▼▼▼ F3 (Norm) ESC 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	CTRL F3 (SET UP) ▼▼▼▼▼▼▼▼▼▼	
	F1 (Fix) 3 EXE ESC 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 rounded off to the number of decimal places you specify.	OPTN F5 (NUM) 4 (Rnd) EXE	28.571
	×	Ans × ☐
	14 EXE	399.994

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, Seq, Min, Max, Median, Mean, Augment, Mat→List, P(, Q(, R(, t(, List

Composite functions[1] fn, **Y**n, **r**n, **X**tn, **Y**tn, **X**n

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, angle unit °, ^{r}, ^{g}

---

[1] You can combine the contents of multiple function memory (fn) locations or graph memory (**Y**n, **r**n, **X**tn, **Y**tn, **X**n) locations into composite functions. Specifying fn1(fn2), for example, results in the composite function fn1∘fn2 (see page 5-3-3).
A composite function can consist of up to five functions.

③ Power/root ^(x^y), $\sqrt[x]{\ }$

④ Fractions $a^b/_c$

⑤ Abbreviated multiplication format in front of π, memory name, or variable name.
2π, 5A, Xmin, F Start, etc.

⑥ Type B functions
With these functions, the function key is pressed and then the value is entered.
$\sqrt{\ }$, $\sqrt[3]{\ }$, log, In, e^x, 10^x, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, (–), d, h, b, o, Neg, Not, Det, Trn, Dim, Identity, Sum, Prod, Cuml, Percent, ⊿List, Abs, Int, Frac, Intg, Arg, Conjg, ReP, ImP

⑦ Abbreviated multiplication format in front of Type B functions
$2\sqrt{3}$, A log2, etc.

⑧ Permutation, combination $n\mathrm{P}r$, $n\mathrm{C}r$

⑨ ×, ÷

⑩ +, –

⑪ Relational operators >, <, ≥, ≤

⑫ Relational operators =, ≠

⑬ and (bitwise operation)

⑭ xnor, xor (bitwise operations)

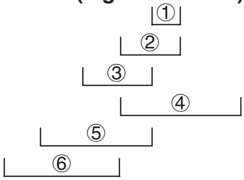
⑮ or (bitwise operation)

⑯ And (logical operation)

⑰ Or (logical operation)

● ● ● ● ●

Example **$2 + 3 \times (\log \sin 2\pi^2 + 6.8) = 22.07101691$ (angle unit = Rad)**



When functions with the same priority are used in series, execution is performed from right to left.
$e^x\mathrm{In}\sqrt{120} \rightarrow e^x\{\mathrm{In}(\sqrt{120})\}$

Otherwise, execution is from left to right.

Compound functions are executed from right to left.

Anything contained within parentheses receives highest priority.

Multiplication Operations without a Multiplication Sign

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

- Before coordinate transformation and Type B functions (① on page 2-1-3 and ⑥ on page 2-1-4), except for negative signs

● ● ● ● ●
Example **2sin30, 10log1.2, 2√ , 2Pol(5, 12), etc.**

- Before constants, variable names, memory names

● ● ● ● ●
Example **2π, 2AB, 3Ans, $3Y_1$, etc.**

- Before an open parenthesis

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

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 $\pm 9.999999999 \times 10^{99}$ (Ma ERROR).
- 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 an improper data type is specified for the argument of a function calculation (Ma ERROR).
- When the capacity of the numeric value stack or command stack is exceeded (Stack 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 (Syntax ERROR). For example, 5 × × 3 EXE.

Other errors can occur during program execution. Most of the calculator's keys are inoperative while an error message is displayed.

Press ESC to clear the error and display the error position (see page 1-3-4).

See the "Error Message Table" on page α-1-1 for information on other errors.

- When you try to perform a calculation that causes memory capacity to be exceeded (Memory ERROR).
- When you use a command that requires an argument, without providing a valid argument (Argument ERROR).
- When an attempt is made to use an illegal dimension during matrix calculations (Dimension ERROR).
- When you are in the real mode and an attempt is made to perform a calculation that produces a complex number solution. Note that “Real” is selected for the Complex Mode setting on the SET UP Screen (Non-Real 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: $\boxed{1}$, $\boxed{2}$, $\boxed{3}$, sin, cos, tan, log, In, $\sqrt{\ }$, and π. Some of the functions that take up two bytes are d/dx(, Mat, Xmin, If, For, Return, DrawGraph, SortA(, PxlOn, Sum, and a_{n+1}.

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

The allowable range for both input and output values is 15 digits for the mantissa and two digits for the exponent. Internal calculations are also performed using a 15-digit mantissa and two-digit exponent.

2-2 Special Functions

Calculations Using Variables

Example	Operation	Display
	193.2 → ALPHA X,θ,T (A) EXE	**193.2**
193.2 ÷ 23 = 8.4	ALPHA X,θ,T (A) ÷ **23** EXE	**8.4**
193.2 ÷ 28 = 6.9	ALPHA X,θ,T (A) ÷ **28** EXE	**6.9**

Memory

• Variables

This calculator comes with 28 variables as standard. You can use variables to store values you want to use 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.

• To assign a value to a variable

[value] → [variable name] EXE

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Example **To assign 123 to variable A**

AC 1 2 3 → ALPHA X,θ,T (A) EXE

```
123→A
                 123
```

● ● ● ● ●

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

AC ALPHA X,θ,T (A) + 4 5 6 → ALPHA
log (B) EXE

```
A+456→B
                 579
```

Variable contents are retained even when you turn power off.

• To display the contents of a variable

● ● ● ● ●

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

AC ALPHA X,θ,T (A) EXE

```
A
                 123
```

• To clear a variable

● ● ● ● ●

Example **To clear variable A**

AC 0 → ALPHA X,θ,T (A) EXE

```
0→A
                   0
```

• To assign the same value to more than one variable

[value] → [first variable name[*1]] OPTN F6 (▷) F6 (▷) F4 (SYBL) 3 (~) [last variable name[*1]] EXE

● ● ● ● ●

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

AC 1 0 → ALPHA X,θ,T (A)
OPTN F6 (▷) F6 (▷) F4 (SYBL) 3 (~)
ALPHA tan (F) EXE

```
10→A~F
                  10
```

• Function Memory **[OPTN]-[FMEM]**

Function memory (f_1~f_{20}) is convenient for temporary storage of often-used expressions. For longer term storage, we recommend that you use the GRPH • TBL Mode for expressions and the PRGM Mode for programs.

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

[*1] You cannot use “r” or “θ” as a variable name.

• To store a function

• • • • •

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

(ALPHA X,θ,T (A) + ALPHA log (B))
(ALPHA X,θ,T (A) − ALPHA log (B))

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

OPTN F6 (▷) F5 (FMEM)
1 (Store) 1 EXE

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

• To recall a function

• • • • •

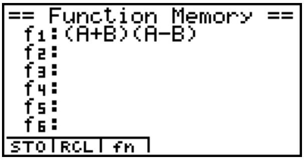
Example **To recall the contents of function memory number 1**

OPTN F6 (▷) F5 (FMEM)
2 (Recall) 1 EXE

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

• To display a list of available functions

OPTN F6 (▷) F5 (FMEM)
4 (SEE)



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

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

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

• To delete a function

● ● ● ● ●

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

AC OPTN F6(▷) F5(FMEM)
1(Store) 1 EXE


```
== 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

● ● ● ● ●

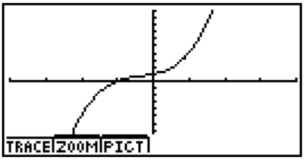
Example **To store $x^3 + 1$, $x^2 + x$ into function memory, and then graph: $y = x^3 + x^2 + x + 1$**

Use the following View Window settings.

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

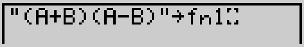
CTRL F3(SET UP) ▼ F1(Y=) ESC
AC X,θ,T ∧ 3 + 1 OPTN F6(▷) F5(FMEM) 1(Store) 1 EXE (stores (x^3 + 1))
ESC AC X,θ,T x^2 + X,θ,T F5(FMEM) 1(Store) 2 EXE (stores (x^2 + x))

ESC AC OPTN F6(▷) F6(▷) F2(SKTCH) 1(Cls) EXE
F2(SKTCH) 4(GRAPH) 1(Y=)
OPTN F6(▷) F5(FMEM) 3(fn) 1 +
F5(FMEM) 3(fn) 2 EXE



- For full details about graphing, see “5. Graphing”.

You can also use → to store a function in function memory in a program.
In this case, you must enclose the function inside of double quotation marks.
The maximum size of the function you can store is 255 bytes.


```
"(A+B)(A-B)"→fn1
```

■ Answer Function

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

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

● ● ● ● ●

Example **123 + 456 = <u>579</u>**
789 – <u>579</u> = 210

AC 1 2 3 + 4 5 6 EXE
7 8 9 – SHIFT (–) (Ans) EXE

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

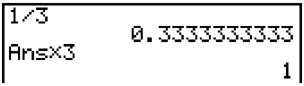
■ Performing Continuous Calculations

Answer memory also lets you use the result of one calculation as one of the arguments in the next calculation.

● ● ● ● ●

Example 1 **1 ÷ 3 =**
1 ÷ 3 × 3 =

AC 1 ÷ 3 EXE
(Continuing) × 3 EXE



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

Continuous calculations can also be used with Type A functions (x^2, x^{-1}, $x!$, page 2-1-3), +, –, ^(x^y), $^{x}\sqrt{\ }$, ° ’ ”, etc.

The largest value that the answer memory can hold is 15 digits for the mantissa and 2 digits for the exponent.

Only numeric values and calculation results can be stored in answer memory.

Answer memory contents are not cleared when you press the AC key or when you switch power off.

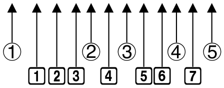
Answer memory contents are not changed by an operation that assigns values to value memory (such as: 5 → ALPHA X,θ,T (A) EXE).

Stacks

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

● ● ● ● ●

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



Numeric Value Stack

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

Command Stack

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

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.

■ Using Multistatements

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

• Colon (:)

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

• Display Result Command (◢)

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

● ● ● ● ●

Example **6.9 × 123 = 848.7**
123 ÷ 3.2 = 38.4375

AC 1 2 3 → ALPHA X,θ,T (A)
SHIFT VARS (PRGM) F6 (▷) F6 (▷) F3 (:) 6 • 9
× ALPHA X,θ,T (A) SHIFT VARS (PRGM) F4 (◢)
ALPHA X,θ,T (A) ÷ 3 • 2 EXE

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

EXE

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

The final result of a multistatement is always displayed, regardless of whether the calculation 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 Specifying the Angle Unit and Display Format

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

[SET UP]- [Angle]

1. On the Set Up screen, highlight “Angle”.
2. Press the function key for the angle unit you want to specify, then press ESC.
   - {**Deg**}/{**Rad**}/{**Gra**} ... {degrees}/{radians}{grads}
   - 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

[SET UP]- [Display]

1. On the Set Up screen, highlight “Display”.
2. Press the function key for the item you want to set, then press ESC.
   - {**Fix**}/{**Sci**}/{**Norm**}/{**Eng**} ... {fixed number of decimal places specification}/{number of significant digits specification}/{normal display}/{Engineering Mode}

• To specify the number of decimal places (Fix)

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Example **To specify two decimal places**

F1(Fix) 2 EXE

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

Display :Fix2

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

• To specify the number of significant digits (Sci)

● ● ● ● ●

Example **To specify three significant digits**

F2(Sci) 3 EXE

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

```
Display      :Sci3
```

• To specify the normal display (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)>$|x|$, $|x| \geqq 10^{10}$

AC 1 ÷ 2 0 0 EXE

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

(Norm 1)

```
1/200
                0.005
```

(Norm 2)

• To specify the engineering notation display (Eng Mode)

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

You can use the following symbols to convert values to engineering notation, such as 2,000 (= 2×10^3) → 2k.

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

Displayed values are rounded off to the number of significant digits you specify.

Specifying 0 makes the number of significant digits 10.

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.

2-4 Function Calculations

■ Function Menus

This calculator includes five function menus that give you access to scientific functions 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 • MAT Mode.

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

- {**Abs**} ... {select this item and input a value to obtain the absolute value of the value.}
- {**Int**}/{**Frac**} ... select the item and input a value to extract the {integer}/{fraction} part.
- {**Rnd**} ... {rounds off the value used for internal calculations to 10 significant digits (to match the value in the Answer Memory), or to the number of decimal places (Fix) and number of significant digits (Sci) specified by you.}
- {**Intg**} ... {select this item and input a value to obtain the largest integer that is not greater than the value.}
- {**E-SYM**} ... {engineering symbol}
  - {**m**}/{**µ**}/{**n**}/{**p**}/{**f**} ... {milli (10^{-3})}/{micro (10^{-6})}/{nano (10^{-9})}/{pico (10^{-12})}/{femto (10^{-15})}
  - {**k**}/{**M**}/{**G**}/{**T**}/{**P**}/{**E**} ... {kilo (10^{3})}/{mega (10^{6})}/{giga (10^{9})}/{tera (10^{12})}/{peta (10^{15})}/{exa (10^{18})}

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

- {***x!***} ... {press after inputting a value to obtain the factorial of the value.}
- {***n*Pr**}/{***n*Cr**} ... {permutation}/{combination}
- {**Ran#**}... {pseudo random number generation (0 to 1)}
- {**P(**}/{**Q(**}/{**R(**} ... normal probability {P(t)}/{Q(t)}/{R(t)}
- {t(} ... {value of normalized variate $t(x)$}

- **Hyperbolic Calculations (HYP)** **[OPTN]-[HYP]**
  - {**sinh**}/{**cosh**}/{**tanh**} ... hyperbolic {sine}/{cosine}/{tangent}
  - {**sinh**$^{-1}$}/{**cosh**$^{-1}$}/{**tanh**$^{-1}$} ... inverse hyperbolic {sine}/{cosine}/{tangent}

- **Angle Units, Coordinate Conversion, Sexagesimal Operations (ANGL)**
[OPTN]-[ANGL]
  - {**°**}/{**r**}/{**g**} ... {degrees}/{radians}/{grads} for a specific input value
  - {**° ’ ”**} ... {specifies degrees (hours), minutes, seconds when inputting a degrees/minutes/seconds value}
  - {**►DMS**} ... {converts decimal value to sexagesimal value}
  - {**Pol(**}/{**Rec(**} ... {rectangular-to-polar}/{polar-to-rectangular} coordinate conversion

---

- **Instant Functions**
  - {↼° ’ ”} ... {converts decimal value to degrees/minutes/seconds value}
  - {**ENG**}/{↼**ENG**} ... shifts the decimal place of the displayed value three digits to the {left}/{right} and {decreases}/{increases} the exponent by three.
When you are using engineering notation, the engineering symbol is also changed accordingly.
  - The {↼° ’ ” }, {ENG} and {↼ENG} menu operations are available only when there is a calculation result on the display.

Angle Units

To change the angle unit of an input value, first press OPTN F3 (ANGL). On the pull-up menu that appears, select “○”, “r”, or “g”.

- Be sure to specify Comp for Mode in the SET UP screen.

Example	Operation
To convert 4.25 rad to degrees: 243.5070629	CTRL F3 (SET UP) ▼ ▼ ▼ ▼ F1 (Deg) ESC **4.25** OPTN F6 (▷) F3 (ANGL) 2 (r) EXE
47.3° + 82.5rad = 4774.20181°	**47.3** + **82.5** OPTN F6 (▷) F3 (ANGL) 2 (r) EXE

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

Trigonometric and Inverse Trigonometric Functions

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

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

- Be sure to specify Comp for Mode in the SET UP screen.

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

*1 × can be omitted.

*2 Input of leading zero is not necessary.

Logarithmic and Exponential Functions

- Be sure to specify Comp for Mode in the SET UP screen.

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

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

Hyperbolic and Inverse Hyperbolic Functions

- Be sure to specify Comp for Mode in the SET UP screen.

Example	Operation
sinh 3.6 = 18.28545536	OPTN F6 (▷) F2 (HYP) 1 (sinh) **3.6** EXE
cosh 1.5 – sinh 1.5 = 0.2231301601 = $e^{-1.5}$ (Display: –1.5) (Proof of cosh x ± sinh $x = e^{\pm x}$)	OPTN F6 (▷) F2 (HYP) 2 (cosh) **1.5** − F2 (HYP) 1 (sinh) **1.5** EXE ln SHIFT (−) (Ans) EXE
$\cosh^{-1}\left(\frac{20}{15}\right) = 0.7953654612$	OPTN F6 (▷) F2 (HYP) 5 (cosh^{-1}) (**20** ÷ **15**) EXE
Determine the value of x when tanh 4 x = 0.88	
$x = \frac{\tanh^{-1} 0.88}{4}$ $= 0.3439419141$	OPTN F6 (▷) F2 (HYP) 6 (tanh^{-1}) **0.88** ÷ **4** EXE

Other Functions

- Be sure to specify Comp for Mode in the SET UP screen.

Example	Operation
$\sqrt{2}+\sqrt{5}=3.65028154$	SHIFT x^2 (√) **2** + SHIFT x^2 (√) **5** EXE
$\sqrt{(3+i)}=$ 1.755317302 +0.2848487846i	SHIFT x^2 (√) (3 + SHIFT 0 (i)) EXE
$(-3)^2=(-3)\times(-3)=9$	((−) **3**) x^2 EXE
$-3^2=-(3\times3)=-9$	(−) **3** x^2 EXE
$\dfrac{1}{\frac{1}{3}-\frac{1}{4}}=12$	(**3** SHIFT) (x^{-1}) − **4** SHIFT) (x^{-1})) SHIFT) (x^{-1}) EXE
8! (= 1 × 2 × 3 × .... × 8) = 40320	**8** OPTN F6 (▷) F1 (PROB) 1 (x!) EXE
$\sqrt[3]{36\times42\times49}=42$	SHIFT (($\sqrt[3]{\ }$) (**36** × **42** × **49**) EXE
What is the absolute value of the common logarithm of $\frac{3}{4}$? $\lvert\log\frac{3}{4}\rvert=0.1249387366$	OPTN F5 (NUM) 1 (Abs) log (**3** ÷ **4**) EXE
What is the integer part of – 3.5? – 3	OPTN F5 (NUM) 2 (Int) (−) **3.5** EXE
What is the decimal part of – 3.5? – 0.5	OPTN F5 (NUM) 3 (Frac) (−) **3.5** EXE
What is the nearest integer not exceeding – 3.5? – 4	OPTN F5 (NUM) 5 (Intg) (−) **3.5** EXE

Random Number Generation (Ran#)

This function generates a 10-digit truly random or sequentially random number that is greater than zero and less than 1.

- A truly random number is generated if you do not specify anything for the argument.

Example	Operation
Ran # (Generates a random number.)	OPTN F6 (▷) F1 (PROB) 4 (Ran#) EXE
(Each press of EXE generates a new random number.)	EXE EXE

- Specifying an argument from 1 to 9 generates random numbers based on that sequence.
- Specifying an argument of 0 initializes the sequence.*[1]

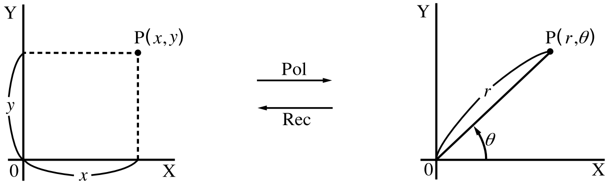
Example	Operation
Ran# 1 (Generates the first random number in sequence 1.)	F1 (PROB) 4 (Ran#) 1 EXE
(Generates the second random number in sequence 1.)	EXE
Ran# 0 (Initializes the sequence.)	F1 (PROB) 4 (Ran#) 0 EXE
Ran# 1 (Generates the first random number in sequence 1.)	F1 (PROB) 4 (Ran#) 1 EXE

---

*[1] Changing to a different sequence or generating a totally random number (without an argument) initializes the sequence.

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).
- Be sure to specify Comp for Mode in the SET UP screen.

Example	Operation
Calculate r and θ° when x = 14 and y = 20.7 1 $\boxed{24.989}$ → 24.98979792 (r) 2 55.928 → 55.92839019 (θ)	CTRL F3(SET UP) ▼ ▼ ▼ ▼ F1(Deg) ESC OPTN F6(▷) F3(ANGL) 6(Pol() **14** , **20.7**) EXE
Calculate x and y when r = 25 and θ = 56° 1 $\boxed{13.979}$ → 13.97982259 (x) 2 20.725 → 20.72593931 (y)	CTRL F3(SET UP) ▼ ▼ ▼ ▼ F1(Deg) ESC OPTN F6(▷) F3(ANGL) 7(Rec() **25** , **56**) EXE

Permutation and Combination

- **Permutation**

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

- **Combination**

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

- Be sure to specify Comp for Mode in the SET UP screen.

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

Formula	Operation
$_{10}P_4 = 5040$	**10** OPTN F6 (▷) F1 (PROB) 2 ($_nP_r$) **4** EXE

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

Formula	Operation
$_{10}C_4 = 210$	**10** OPTN F6 (▷) F1 (PROB) 3 ($_nC_r$) **4** EXE

Fractions

- Fractional values are displayed with the integer first, followed by the numerator and then the denominator.
- Be sure to specify Comp for Mode in the SET UP screen.

Example	Operation
$\frac{2}{5}+3\frac{1}{4}=3\frac{13}{20}$ (Display: 3⌟13⌟20) $=3.65$	**2** $\boxed{a\frac{b}{c}}$ **5** $\boxed{+}$ **3** $\boxed{a\frac{b}{c}}$ **1** $\boxed{a\frac{b}{c}}$ **4** $\boxed{\text{EXE}}$ $\boxed{a\frac{b}{c}}$ (Conversion to decimal) $\boxed{a\frac{b}{c}}$ (Conversion to fraction)
$\frac{1}{2578}+\frac{1}{4572}=6.066202547\times10^{-4}$ (Display: 6.066202547E–04[*1]) (Norm 1 display format)	**1** $\boxed{a\frac{b}{c}}$ **2578** $\boxed{+}$ **1** $\boxed{a\frac{b}{c}}$ **4572** $\boxed{\text{EXE}}$
$\frac{1}{2}\times0.5=0.25$[*2] $=\frac{1}{4}$	**1** $\boxed{a\frac{b}{c}}$ **2** $\boxed{\times}$ **.5** $\boxed{\text{EXE}}$ $\boxed{a\frac{b}{c}}$
$1.5+2.3i=1\frac{1}{2}+2\frac{3}{10}i$ (Display: 1⌟1⌟2 +2⌟3⌟10**i**)	**1.5** $\boxed{+}$ **2.3** $\boxed{\text{SHIFT}}$ $\boxed{0}$ (i) $\boxed{\text{EXE}}$ $\boxed{a\frac{b}{c}}$ $\boxed{a\frac{b}{c}}$ [*3]
$\frac{1}{\frac{1}{3}+\frac{1}{4}}=1\frac{5}{7}$ (Display: 1⌟5⌟7)	**1** $\boxed{a\frac{b}{c}}$ $\boxed{(}$ **1** $\boxed{a\frac{b}{c}}$ **3** $\boxed{+}$ **1** $\boxed{a\frac{b}{c}}$ **4** $\boxed{)}$ $\boxed{\text{EXE}}$ [*4]

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

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

[*3] Pressing $\boxed{a\frac{b}{c}}$ once when converting the decimal part of a complex number to a fraction first displays the real part and imaginary part on separate lines.

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

■ Engineering Notation Calculations

Input engineering symbols using the engineering notation menu.

- Be sure to specify Comp for Mode in the SET UP screen.

Example	Operation
	CTRL F3(SET UP) ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ ▼ F4(Eng) ESC
999k (kilo) + 25k (kilo) = 1.024M (mega)	**999** OPTN F5(NUM) 6(E-SYM) 6(k) + **25** F5(NUM) 6(E-SYM) 6(k) EXE
9 ÷ 10 = 0.9 = 900m (milli)	**9** ÷ **10** EXE
= 0.9	OPTN F6(▷) F6(▷) F6(▷) F3(←ENG)*1
= 0.0009k (kilo)	F3(←ENG)*1
= 0.9	F2(ENG)*2
= 900m	F2(ENG)*2

*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.

2-5 Numerical Calculations

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

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

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

Solve calculations

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

Solve($f(x)$, n, a, b) (a: lower limit, b: upper limit, n: initial estimated value)

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

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

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

  An Error (Iteration ERROR) occurs when there is no convergence of the solution.

■ Differential Calculations **[OPTN]-[CALC]-[*d*/*dx*]**

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

OPTN F4 (CALC) 1 (d/dx) $f(x)$, a , tol)

(a: point for which you want to determine the derivative, tol: tolerance)

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

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.

Using Differential Calculation in a Graph Function

- Omitting the tolerance (tol) value when using the differential command inside of a graph function simplifies the calculation for drawing the graph. In such a case, precision is sacrificed for the sake of faster drawing. The tolerance value is specified, the graph is drawn with the same precision obtained when you normally perform a differential calculation.
- You can also omit input of the derivative point by using the following format for the differential graph: Y2=d/dx(Y1). In this case, the value of the X variable is used as the derivative point.

• • • • •

Example **To determine the derivative at point x = 3 for the function $y = x^3 + 4x^2 + x - 6$, with a tolerance of "*tol*" = 1E – 5**

Input the function $f(x)$.

AC OPTN F4 (CALC) 1 (*d/dx*) X,θ,T ^ 3 + 4 X,θ,T x^2 + X,θ,T − 6 ,

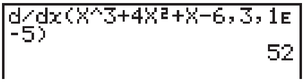
Input point $x = a$ for which you want to determine the derivative.

3 ,

Input the tolerance value.

1 EXP (−) 5)

EXE



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

In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.
Input of the tolerance (*tol*) value and the closing parenthesis can be omitted. If you omit tolerance (*tol*) value, the calculator automatically uses a value for *tol* as 1E-10.
Specify tolerance (*tol*) value of 1E-14 or less. An error (Iteration ERROR) occurs whenever no solution that satisfies the tolerance value can be obtained.
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 or divided with each other.

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

Therefore:

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

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

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

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

$$\frac{d}{dx}(\sin x + \cos x,\ \sin 0.5,\ 1\text{E} - 8), \text{ etc.}$$

You cannot use a differential, quadratic differential, integration, Σ, maximum/minimum value or solve calculation expression inside a differential calculation term.

Pressing AC during calculation of a differential (while the cursor is not shown on the display) interrupts the calculation.

Always use radians (Rad Mode) as the angle unit when performing trigonometric differentials.

Quadratic Differential Calculations **[OPTN]-[CALC]-[d^2/dx^2]**

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

OPTN F4 (CALC) 2 (d^2/dx^2) $f(x)$, a , tol)

(a: differential coefficient point, tol: tolerance)

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

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

$$f''(a) = \frac{2f(a+3h) - 27f(a+2h) + 270f(a+h) - 490f(a) + 270f(a-h) - 27f(a-2h) + 2f(a-3h)}{180h^2}$$

In this expression, values for "sufficiently small increments of h" are used to obtain a value that approximates $f''(a)$.

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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 tolerance tol = 1E – 5

Input the function $f(x)$.

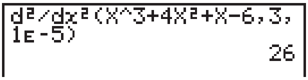
AC OPTN F4 (CALC) 2 (d^2/dx^2) X,θ,T ^ 3 +
4 X,θ,T x^2 + X,θ,T − 6 ,

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

3 ,

Input the tolerance value.

1 EXP (−) 5)
EXE



```
d²/dx²(X^3+4X²+X-6,3,
1E-5)
                   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 tolerance (tol) value 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.

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

Therefore:

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

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

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

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

$$\frac{d^2}{dx^2} (\sin x + \cos x, \sin 0.5, 1\text{E} - 8), \text{ etc.}$$

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

Specify tolerance (*tol*) value of 1E-14 or less. An error (Iteration ERROR) occurs whenever no solution that satisfies the tolerance value can be obtained.

You can interrupt an ongoing quadratic differential calculation by pressing the AC key.

Always use radians (Rad Mode) as the angle unit when performing trigonometric quadratic differentials.

Using Quadratic Differential Calculation in a Graph Function (see page 2-5-2)

Integration Calculations

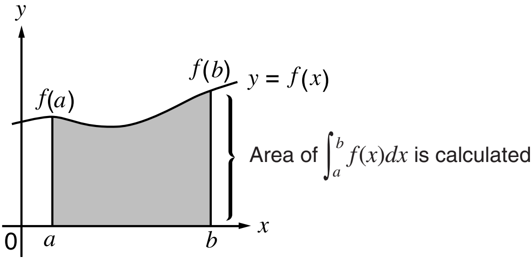
[OPTN]-[CALC]-[$\int dx$]

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

OPTN F4(CALC) 3 ($\int dx$) $f(x)$, a , b , tol)

(a: start point, b: end point, tol: tolerance)

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



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 $a \leqq x \leqq b$, the surface area calculation produces negative values (surface area × – 1).

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

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

Input the function $f(x)$.

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

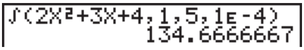
Input the start point and end point.

1 , 5 ,

Input the tolerance value.

1 EXP (–) 4)

EXE



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

• Application of Integration Calculation

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

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

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

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

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

$$\int_{\sin 0.5}^{\cos 0.5} (\sin x + \cos x)\, dx = \int(\sin x + \cos x, \sin 0.5, \cos 0.5, 1\text{E} - 4)$$

In the function $f(x)$, only X can be used as a variable in expressions. Other variables (A through Z, r, θ) are treated as constants, and the value currently assigned to that variable is applied during the calculation.

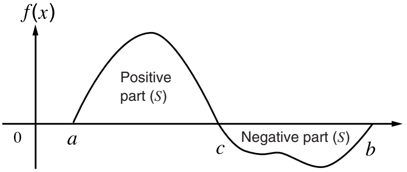
Input of “*tol*” and closing parenthesis can be omitted. If you omit “*tol*,” the calculator automatically uses a default value of 1E-5.

Integration calculations can take a long time to complete.

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

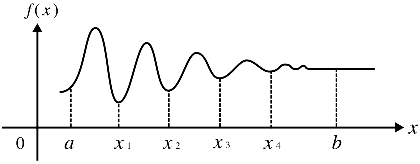
Note the following points to ensure correct integration values.

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



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

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



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

Pressing AC during calculation of an integral (while the cursor is not shown on the display) interrupts the calculation.

Always use radians (Rad Mode) as the angle unit when performing trigonometric integrations.

An error (Iteration ERROR) occurs whenever no solution that satisfies the tolerance value can be obtained.

■ Σ Calculations

[OPTN]-[CALC]-[Σ]

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

OPTN F4 (CALC) 4 (Σ) a_k , k , α , β , n)

$$\Sigma\,(a_k, k, \alpha, \beta, n) = \sum_{k=\alpha}^{\beta} a_k = a_\alpha + a_{\alpha+1} + \ldots\ldots + a_\beta$$

(n: distance between partitions)

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Example **To calculate the following:**

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

Use n = 1 as the distance between partitions.

AC OPTN F4 (CALC) 4 (Σ) ALPHA , (K) x^2
− 3 ALPHA , (K) + 5 ,
ALPHA , (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 (α) of sequence a_k and last term (β) 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: $S_n = \sum_{k=1}^{n} a_k,\ T_n = \sum_{k=1}^{n} b_k$

Possible operations: $S_n + T_n,\ S_n - T_n$, etc.

- Arithmetic and function operations using Σ calculation results

$2 \times S_n$, $\log (S_n)$, etc.

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

Σ (sin$k$, k, 1, 5), etc.

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

Make sure that the value used as the final term β is greater than the value used as the initial term α. Otherwise, an error will occur.

To interrupt an ongoing Σ calculation (indicated when the cursor is not on the display), press the AC key.

■ Maximum/Minimum Value Calculations **[OPTN]-[CALC]-[FMin]/[FMax]**

After displaying the function analysis menu, you can input maximum/minimum calculations using the formats below, and solve for the maximum and minimum of a function within interval $a \leqq x \leqq b$. (a: start point of interval, b: end point of interval, n: precision (n = 1 to 9))

•Minimum Value

OPTN F4(CALC) 5(FMin) $f(x)$, a , b , n)

•Maximum Value

OPTN F4(CALC) 6(FMax) $f(x)$, a , b , n)

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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) 5(FMin) X,θ,T x^2 − 4 X,θ,T + 9 ,

Input the interval a = 0, b = 3.

0 , 3 ,

Input the precision n = 6.

6)

EXE

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

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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) [6](FMax) [(−)] [X,θ,T] [x^2] [+] [2] [X,θ,T] [+] [2] [,]

Input the interval a = 0, b = 3.

[0] [,] [3] [,]

Input the precision n = 6.

[6] [)]

[EXE]

```
Ans
 1[     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 can be omitted.

Discontinuous points or sections with drastic fluctuation can adversely affect precision or even cause an error.

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

Inputting a larger value for n increases the precision of the calculation, but it also increases the amount of time required to perform the calculation.

The value you input for the end point of the interval (b) must be greater than the value you input for the start point (a). Otherwise an error occurs.

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.

2-6 Complex Number Calculations

You can perform addition, subtraction, multiplication, division, parentheses calculations, function calculations, and memory calculations with complex numbers just as you do with the manual calculations described on pages 2-1-1 and 2-4-6.

You can select the complex number calculation mode by changing the Complex Mode item on the SET UP screen to one of the following settings.

- {**Real**} ... Calculation in the real number range only[*1]
- {***a+bi***} ... Performs complex number calculation and displays results in rectangular form
- {***re^θi***} ... Performs complex number calculation and displays results in polar form[*2]

Press OPTN F3 (CPLX) to display the complex calculation number menu, which contains the following items.

- {**Abs**}/{**Arg**} ... obtains {absolute value}/{argument}
- {**Conjg**} ... {obtains conjugate}
- {**ReP**}/{**ImP**} ... {real}/{imaginary} part extraction
- {**►*re^θi***}/{**►*a+bi***} ... converts the result to {polar}/{linear}

[*1] When there is an imaginary number in the argument, however, complex number calculation is performed and the result is displayed using rectangular form.

Examples:
ln 2i = 0.6931471806 + 1.570796327i
ln 2i + ln (- 2) = (Non-Real ERROR)

[*2] The display range of θ depends on the angle unit set for the Angle item on the SET UP screen.

- Deg ... $-180 < \theta \leqq 180$
- Rad ... $-\pi < \theta \leqq \pi$
- Gra ... $-200 < \theta \leqq 200$

Solutions obtained by the Real and $a+bi$ / re^θi modes are different for power root (x^y) calculations when $x < 0$ and $y = m/n$ when n is an odd number.

Example:
$3\,{}^{x}\!\sqrt{\ }$ (- 8) = – 2 (Real)
= 1 + 1.732050808i($a+bi$ / re^θi)

■ Absolute Value and Argument

[OPTN]-[CPLX]-[Abs]/[Arg]

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

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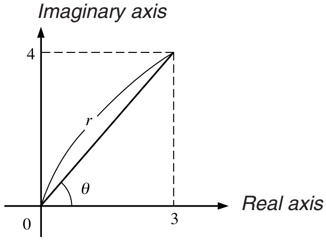
Example **To calculate absolute value (r) and argument (θ) for the complex number 3 + 4i, with the angle unit set for degrees**



AC OPTN F3(CPLX) 1(Abs)
(3 + 4 SHIFT 0(i)) EXE
(Calculation of absolute value)

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

AC OPTN F3(CPLX) 2(Arg)
(3 + 4 SHIFT 0(i)) EXE
(Calculation of argument)

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

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

Conjugate Complex Numbers **[OPTN]-[CPLX]-[Conjg]**

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

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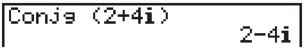
Example **To calculate the conjugate complex number for the complex number 2 + 4*i***

AC OPTN F3(CPLX) 3(Conjg)
(2 + 4 SHIFT 0(i)) EXE


Conjg (2+4i)
2-4i

Extraction of Real and Imaginary Parts **[OPTN]-[CPLX]-[ReP]/[ImP]**

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

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

AC OPTN F3(CPLX) 4(ReP)
(2 + 5 SHIFT 0(i)) EXE
(Real part extraction)


ReP (2+5i)
2

AC OPTN F3(CPLX) 5(ImP)
(2 + 5 SHIFT 0(i)) EXE
(Imaginary part extraction)


ImP (2+5i)
5

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 part and imaginary part are displayed on separate lines.

When either the real part or imaginary part of a complex number equals zero, that part is not displayed in rectangular form.

18 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}, ^(x^y), $\sqrt[3]{\ }$, $\sqrt[x]{\ }$, In, log, 10^x, e^x, sin, cos, tan, sin^{-1}, cos^{-1}, tan^{-1}, sinh, cosh, tanh, sinh^{-1}, cosh^{-1}, tanh^{-1}
Int, Frac, Rnd, Intg, Fix, Sci, ENG, ←ENG, ° ’ ”, ←° ’ ”, $a\,{}^{b}/_{c}$, d/c

■ Polar Form and Rectangular Transformation [OPTN]-[CPLX]-[►*re*^*θi*]

Use the following procedure to transform a complex number displayed in rectangular form to polar form, and vice versa.

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Example **To transform the rectangular form of complex number 1 + $\sqrt{3}i$ to its polar form**

AC 1 + (SHIFT x^2 (√) 3) SHIFT 0 (*i*)
OPTN F3 (CPLX) 6 (►*re*^*θi*) EXE

```
1+(√3)i▸re^θi
          2e60i
```

2-7 Binary, Octal, Decimal, and Hexadecimal Calculations with Integers

You can use the **RUN • MAT 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 bitwise operations.

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

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

- 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 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
Keys	X,θ,T	log	ln	sin	cos	tan

- 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

[SET UP]- [Mode] -[Dec]/[Hex]/[Bin]/[Oct]

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

2. Press CTRL F3 (SET UP) and then specify the default number system by pressing F2 (Dec), F3 (Hex), F4 (Bin), or F5 (Oct).

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

- {**d~o**}/{**LOGIC**}/{**DISP**}/{**SYBL**} ... {number system specification}/{bitwise operation}/{decimal/hexadecimal/binary/octal conversion}/{symbol} menu

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 specify a number system for an input value

You can specify a number system for each individual value you input. 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.

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

• To input values of mixed number systems

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

CTRL F3 (SET UP) F3 (Hex) ESC
AC F1 (d~o) 1 (d) 1 2 3 EXE

```
d123
                0000007B
```

F1 (d~o) 3 (b) 1 0 1 0 EXE

```
b1010
                0000000A
```

Arithmetic Operations

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

CTRL F3 (SET UP) F4 (Bin) ESC
AC 1 0 1 1 1 +
1 1 0 1 0 EXE

```
10111+11010
      0000000000110001
```

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

CTRL F3 (SET UP) F2 (Dec) ESC
AC F1 (d~o) 4 (o) 1 2 3 ×
F1 (d~o) 2 (h) A B C *1 EXE

```
o123×hABC
                   228084
```

F3 (DISP) 2 (Hex) EXE

```
Ans▸Hex
                 00037AF4
```

■ Negative Values and Bitwise Operations

Press F2 (LOGIC) to display a menu of negation and bitwise operators.

- {**Neg**} ... {negation}*2
- {**Not**}/{**and**}/{**or**}/{**xor**}/{**xnor**} ... {NOT}*3/{AND}/{OR}/{XOR}/{XNOR}*4

● Negative Values

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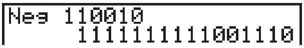
Example **To determine the negative of 110010_2**

CTRL F3 (SET UP) F4 (Bin) ESC
AC F2 (LOGIC) 1 (Neg)
1 1 0 0 1 0 EXE



```
Neg 110010
     1111111111001110
```

●Bitwise Operations

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

CTRL F3 (SET UP) F3 (Hex) ESC
AC 1 2 0 F2 (LOGIC)
3 (and) A D *1 EXE

```
120andAD
                 00000020
```

---

*1 See page 2-7-1.
*2 two's complement
*3 one's complement (bitwise complement)
*4 bitwise AND, bitwise OR, bitwise XOR, bitwise XNOR

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

CTRL F3 (SET UP) F5 (Oct) ESC
AC 3 6 F2 (LOGIC)
4 (or) F1 (d~o) 3 (b)
1 1 1 0 EXE

```
36orb1110
          00000000036
```

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

CTRL F3 (SET UP) F3 (Hex) ESC
AC F2 (LOGIC) 2 (Not)
2 F F F E D[1] EXE

```
Not 2FFFED
        FFD00012
```

● Number System Transformation

Press F3 (DISP) to display a menu of number system transformation functions.

- {►**Dec**}/{►**Hex**}/{►**Bin**}/{►**Oct**} ... transformation of displayed value to its {decimal}/{hexadecimal}/{binary}/{octal} equivalent

---

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

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

AC CTRL F3 (SET UP) F2 (Dec) ESC
F1 (d~o) 1 (d) 2 2 EXE

```
d22
                   22
```

F3 (DISP) 3 (►Bin) EXE

```
     0000000000010110
```

F3 (DISP) 4 (►Oct) EXE

```
          00000000026
```

---

[1] See page 2-7-1.

2-8 Matrix Calculations

From the Main Menu, enter the **RUN • MAT** Mode, and press F1(MAT) to perform 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 multiplication 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
- Absolute value, argument, complex conjugate calculation for a matrix with complex number components
- Real part and complex number part extraction of a matrix with complex number components

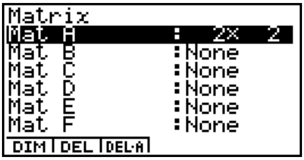
The maximum number of rows that can be specified for a matrix is 255, and the maximum number of columns is 255.

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

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

Inputting and Editing Matrices

Pressing F1(MAT) displays the matrix editor screen. Use the matrix editor to input and edit matrices.



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

$m \times n$ … m (row) × n (column) matrix

None… no matrix preset

- {**DIM**} ... {specifies the matrix dimensions (number of cells)}
- {**DEL**}/{**DEL·A**} ... deletes {a specific matrix}/{all matrices}

• 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 (size) 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

F1(DIM)

Specify the number of rows.

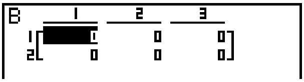
2 EXE

Specify the number of columns.

3 EXE

Dimension m×n
m :2
n :3

EXE



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

- All of the cells of a new matrix contain the value 0.

If "Memory 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

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

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

▼ (Selects Mat B.)

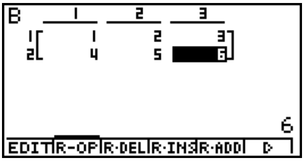
Matrix
Mat A : 2× 2
Mat B : 2× 3

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 moves to the next cell to the right.)



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

6

You can input complex numbers into the cell of a matrix.

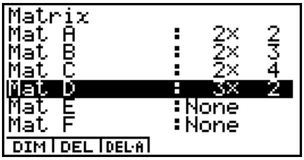
Displayed cell values show positive integers up to six digits, and negative integers up to five digits (one digit used for the negative sign). Exponential values are shown with up to two digits for the exponent. Fractional values are not displayed.

You can see the entire value assigned to a cell by using the cursor keys to move the highlighting to the cell whose value you want to view.

The amount of memory required for a matrix is 9 bytes per cell. This means that a 3 × 3 matrix requires 81 bytes of memory (3 × 3 × 9 = 81). Inputting complex numbers into a matrix doubles the amount of memory used.

• Deleting Matrices

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



```
Matrix
Mat A          :  2×  2
Mat B          :  2×  3
Mat C          :  2×  4
Mat D          :  3×  2
Mat E          :None
Mat F          :None
DIM DEL DEL·A
```

• 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 F2 (DEL).

3. Press EXE (Yes) to delete the matrix or ESC (No) to abort the operation without deleting anything.

• To delete all matrices

1. While the Matrix list is on the display, press F3 (DEL·A).

2. Press EXE (Yes) to delete all matrices in memory or ESC (No) to abort the operation without deleting anything.

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

Inputting the format or changing the dimensions of a matrix deletes its current contents.

■ Matrix Cell Operations

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

1. While the Matrix list is on the display, use ⏶ and ⏷ to highlight the name of the matrix you want to use.
   You can jump to a specific matrix by inputting the letter that corresponds to the matrix name. Inputting ALPHA 8 (N), for example, jumps to Mat N.
   Pressing SHIFT (−) (Ans) jumps to the Matrix current Memory.
2. Press EXE and the function menu with the following items appears.
   - {**EDIT**} ... {cell editing screen}
   - {**R-OP**} ... {row operation menu}
   - {**R•DEL**}/{**R•INS**}/{**R•ADD**} ... row {delete}/{insert}/{add}
   - {**C•DEL**}/{**C•INS**}/{**C•ADD**} ... column {delete}/{insert}/{add}

All of the following examples use Matrix A.

• Row Calculations

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

- {**Swap**} ... {row swap}
- {×**Row**} ... {product of specified row and scalar}
- {×**Row+**} ... {addition of one row and the product of a specified row with a scalar}
- {**Row+**} ... {addition of specified row to another row}

• To swap two rows

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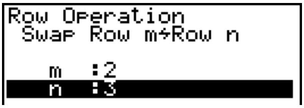
Example **To swap rows two and three of the following matrix :**

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

F2 (R-OP) 1 (Swap)

Input the number of the rows you want to swap.

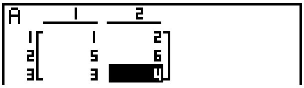
2 EXE 3 EXE



Row Operation
Swap Row m↔Row n

m :2
n :3

F6 (EXE) (or EXE)



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

• To calculate the scalar multiplication of a row

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

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

F2(R-OP) 2(×Row)

Input multiplier value.

4 EXE

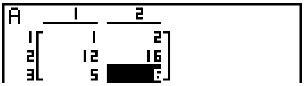
Specify row number.

2 EXE

F6(EXE) (or EXE)

```
Row Operation
 k×Row m→Row m

   k  :4
   m  :2
```



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

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

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

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

F2(R-OP) 3(×Row+)

Input multiplier value.

4 EXE

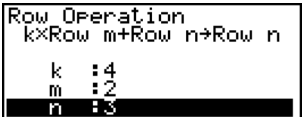
Specify number of row whose product should be calculated.

2 EXE

Specify number of row where result should be added.

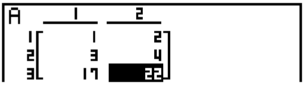
3 EXE

F6(EXE) (or EXE)



```
Row Operation
 k×Row m+Row n→Row n

   k  :4
   m  :2
   n  :3
```



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

• To add two rows together

● ● ● ● ●

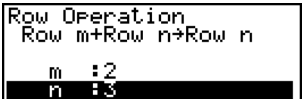
Example **To add row 2 to row 3 of the following matrix :**

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

F2 (R-OP) 4 (Row+)

Specify number of row to be added.

2 EXE



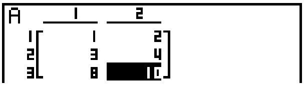
```
Row Operation
 Row m+Row n→Row n

   m  :2
   n  :3
```

Specify number of row to be added to.

3 EXE

F6 (EXE) (or EXE)



```
A     1     2
1[    1     2]
2     3     4
3[    8    10]
```

• Row Operations

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

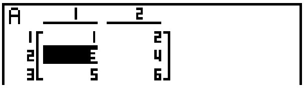
• To delete a row

● ● ● ● ●

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

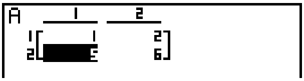
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

▼



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

F3 (R•DEL)



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

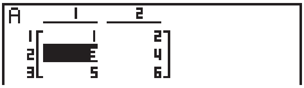
• To insert a row

● ● ● ● ●

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

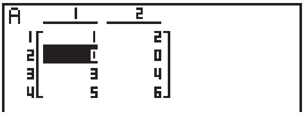
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

▼



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

F4(R•INS)



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

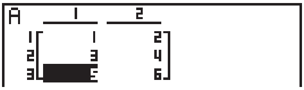
• To add a row

● ● ● ● ●

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

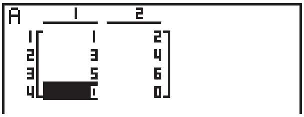
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

▼ ▼



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

F5(R•ADD)



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

• Column Operations

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

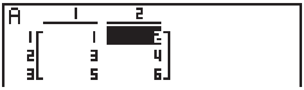
• To delete a column

● ● ● ● ●

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

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

▶



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

F6(▷)F1(C•DEL)

A	1
1	1
2	3
3	5

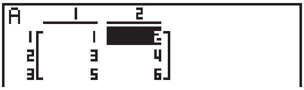
• To insert a column

● ● ● ● ●

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

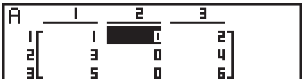
$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{bmatrix}$$

▶



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

F6(▷)F2(C•INS)



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

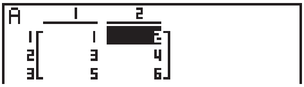
• To add a column

● ● ● ● ●

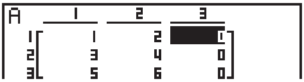
Example **To add a new column to the right of column 2 of the following matrix :**

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

▶



F6 (▷) F3 (C•ADD)



■ Modifying Matrices Using Matrix Commands **[OPTN]-[MAT]**

• To display the matrix commands

1. From the Main Menu, enter the RUN • MAT Mode.

2. Press OPTN to display the option menu.

3. Press F2 (MAT) to display the matrix command menu.

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

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

• Matrix Data Input Format **[OPTN]-[MAT]-[Mat]**

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

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

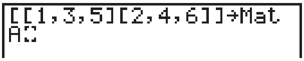
$= [\ [a_{11}, a_{12}, \dots, a_{1n}]\ [a_{21}, a_{22}, \dots, a_{2n}]\ \dots .\ [a_{m1}, a_{m2}, \dots, a_{mn}]\ ]$
$\rightarrow$ Mat [letter A through Z]

● ● ● ● ●

Example 1 To input the following data as Matrix A :

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

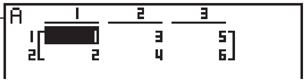
SHIFT + ([ ) SHIFT + ([ ) 1 , 3 , 5
SHIFT − ( ]) SHIFT + ([ ) 2 , 4 , 6
SHIFT − ( ]) SHIFT − ( ]) → OPTN F2 (MAT)
1 (Mat) ALPHA X,θ,T (A)



```
[[1,3,5][2,4,6]]→Mat
A
```

EXE

Matrix name



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

You can also use SHIFT 2 (Mat) in place of OPTN F2 (MAT) 1 (Mat).

The maximum value of both m and n is 255.

An error occurs if memory becomes full as you are inputting data.

You can also use the above format inside a program that inputs matrix data.

• To input an identity matrix **[OPTN]-[MAT]-[Ident]**

Use the Identity command to create an identity matrix.

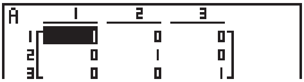
● ● ● ● ●

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

OPTN F2(MAT) 6(Ident)

3 → F2(MAT) 1(Mat) ALPHA X,θ,T(A) EXE

Number of rows/columns



• To check the dimensions of a matrix **[OPTN]-[MAT]-[Dim]**

Use the Dim command 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) 2(Dim)

F2(MAT) 1(Mat) ALPHA X,θ,T(A) EXE

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

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

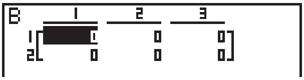
● ● ● ● ●

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

SHIFT ×({) 2 , 3 SHIFT ÷(}) →

OPTN F2(MAT) 2(Dim)

F2(MAT) 1(Mat) ALPHA log(B) EXE



• 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

[OPTN]-[MAT]-[Mat]

Use the following format with the Mat command to specify a cell for value assignment and recall.

Mat X [*m*, *n*]

X .... matrix name (A through Z, or Ans)

m .... row number

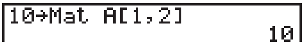
n .... column number

● ● ● ● ●

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) 1 (Mat)
ALPHA X,θ,T (A) SHIFT + ([ ) 1 , 2
SHIFT − ( ]) EXE



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

● ● ● ● ●

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

OPTN F2 (MAT) 1 (Mat)
ALPHA X,θ,T (A) SHIFT + ([ ) 2 , 2
SHIFT − ( ]) × 5 EXE

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

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

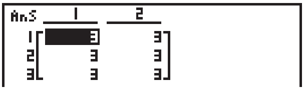
[OPTN]-[MAT]-[Fill]/[Augmnt]

Use the Fill command to fill all the cells of an existing matrix with an identical value and the Augment command 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) 7 (Fill)
3 , F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) EXE
F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) EXE



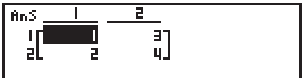
Ans	1	2
1	3	3
2	3	3
3	3	3

• • • • •

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

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

OPTN F2 (MAT) 5 (Augmnt)
F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) ,
F2 (MAT) 1 (Mat) ALPHA log (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 occurs if you try to combine two matrices that have different numbers of rows.

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

[OPTN]-[MAT]-[M→List]

Use the following format with the Mat→List command to specify a column and a list.

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 1 :**

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

OPTN F2 (MAT) 8 (M→List)
F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) , 2)
→ OPTN F1 (LIST) 1 (List) 1 EXE
OPTN F1 (LIST) 1 (List) 1 EXE

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

You can also use SHIFT 1 (List) in place of OPTN F1 (LIST) 1 (List).

You can use Matrix Answer Memory to assign the results of the above matrix input and edit operations to a matrix variable. To do so, use the following syntax.

- Fill (n, Mat α) → Mat β
- Augment (Mat α, Mat β) → Mat γ

In the above, α, β, and γ are any variable names A through Z, and n is any value.
The above does not affect the contents of Matrix Answer Memory.

■ Matrix Calculations **[OPTN]-[MAT]**

Use the matrix command menu to perform matrix calculation operations.

• To display the matrix commands

1. From the Main Menu, enter the RUN • MAT Mode.

2. Press OPTN to display the option menu.

3. Press F2(MAT) to display the matrix command menu.

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

- {**Mat**} ... {Mat command (matrix specification)}
- {**Det**} ... {Det command (determinant command)}
- {**Trn**} ... {Trn command (transpose matrix command)}
- {**Ident**} ... {Identity command (identity matrix input)}

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

• Matrix Arithmetic Operations

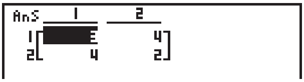
[OPTN]-[MAT]-[Mat]

• • • • •

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

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

AC OPTN F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) +
F2 (MAT) 1 (Mat) ALPHA log (B) EXE



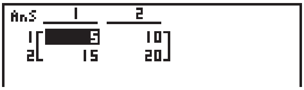
```
AnS    1       2
 1[    3       4]
 2[    4       2]
```

• • • • •

Example 2 **Calculate the product to the following matrix using a multiplier value of 5 :**

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

AC 5 OPTN F2 (MAT) 1 (Mat)
ALPHA X,θ,T (A) EXE

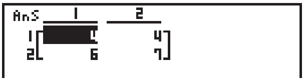


```
AnS    1       2
 1[    5      10]
 2[   15      20]
```

• • • • •

Example 3 **To multiply the two matrices in Example 1 (Matrix A × Matrix B)**

AC OPTN F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) ×
F2 (MAT) 1 (Mat) ALPHA log (B) EXE



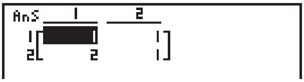
```
AnS    1       2
 1[    4       4]
 2[    6       7]
```

• • • • •

Example 4 **To multiply Matrix A (from Example 1) by a 2 × 2 identity matrix**

AC OPTN F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) ×
F2 (MAT) 6 (Ident) 2 EXE

Number of rows and columns



```
AnS    1       2
 1[    1       1]
 2[    2       1]
```

The two matrices must have the same dimensions in order to be added or subtracted. An error occurs if you try to add or subtract matrices of different dimensions.

For multiplication (Matrix 1 × Matrix 2), the number of columns in Matrix 1 must match the number of rows in Matrix 2. Otherwise, an error occurs.

When performing matrix arithmetic operations, inputting the Identity command at the location of a matrix command (such as Mat A) makes it possible to perform identity matrix calculations.

• Determinant

[OPTN]-[MAT]-[Det]

• • • • •
Example **Obtain the determinant for the following matrix :**

$$\textbf{Matrix A} = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ -1 & -2 & 0 \end{bmatrix}$$

OPTN F2 (MAT) 3 (Det) F2 (MAT) 1 (Mat)
ALPHA X,θ,T (A) EXE

```
Det Mat A
                    -9
```

• Matrix Transposition

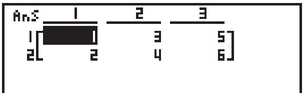
[OPTN]-[MAT]-[Trn]

A matrix is transposed when its rows become columns and its columns become rows.

• • • • •
Example **To transpose the following matrix :**

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

OPTN F2 (MAT) 4 (Trn) F2 (MAT) 1 (Mat)
ALPHA X,θ,T (A) EXE



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

Determinants can be obtained only for square matrices (same number of rows and columns). Trying to obtain a determinant for a matrix that is not square produces an error.

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

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

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

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

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

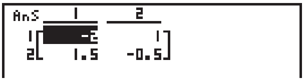
• Matrix Inversion

[OPTN]-[MAT]-[x^{-1}]

• • • • •
Example **To invert the following matrix :**

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

OPTN F2 (MAT) 1 (Mat)
ALPHA X,θ,T (A) SHIFT) (x^{-1}) EXE



```
Ans   1      2
 1[  -2      1]
 2[  1.5  -0.5]
```

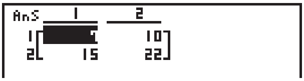
• Squaring a Matrix

[OPTN]-[MAT]-[x^2]

• • • • •
Example **To square the following matrix :**

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

OPTN F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) x^2 EXE



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

Only square matrices (same number of rows and columns) can be inverted. Trying to invert a matrix that is not square produces an error.

A matrix with a determinant of zero cannot be inverted. Trying to invert a matrix with determinant of zero produces an error.

Calculation precision is affected for matrices whose determinant is near zero.

A matrix being inverted must satisfy the conditions shown below.

$$\mathbf{A\,A^{-1} = A^{-1}\,A = E} = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

The following shows the formula used to invert Matrix A into inverse matrix A^{-1}.

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

$$\mathbf{A^{-1}} = \frac{1}{ad - bc} \begin{bmatrix} d & -b \\ -c & a \end{bmatrix}$$

Note that $ad - bc \neq 0$.

• Raising a Matrix to a Power

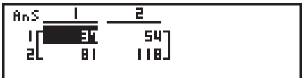
[OPTN]-[MAT]-[^]

• • • • •

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

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

OPTN F2 (MAT) 1 (Mat) ALPHA X,θ,T (A)
^ 3 EXE



```
AnS      1        2
  1[    34       54]
  2[    81      118]
```

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

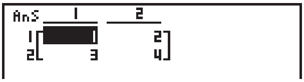
[OPTN]-[NUM]-[Abs]/[Frac]/[Int]/[Intg]

• • • • •

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

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

OPTN F5 (NUM) 1 (Abs)
OPTN F2 (MAT) 1 (Mat) ALPHA X,θ,T (A) EXE



```
AnS      1        2
  1[     1        2]
  2[     3        4]
```

Determinants and inverse matrices are subject to error due to dropped digits.

Matrix operations are performed individually on each cell, so calculations may require considerable time to complete.

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

If a matrix calculation result is too large to fit into Matrix Answer Memory, an error occurs.

You can use the following operation to transfer Matrix Answer Memory contents to another matrix (or when Matrix Answer Memory contains a determinant to a variable).

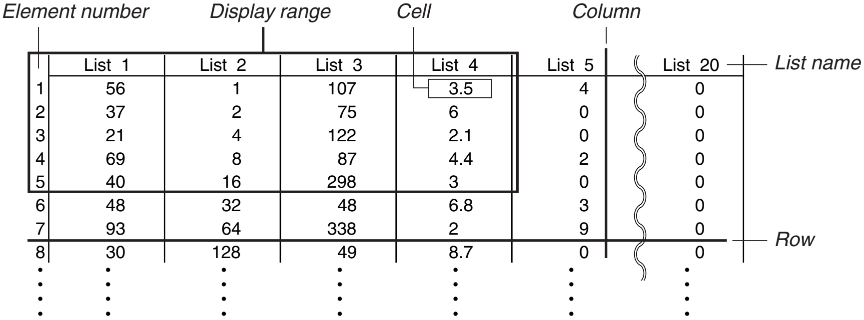
MatAns → Mat α

In the above, α is any variable name A through Z. The above does not affect the contents of Matrix Answer Memory.

Chapter 3

List Function

A list is a storage place for multiple data items.
This calculator lets you store up to 20 lists in a single file, and you can store up to six files in memory. Stored lists can be used in arithmetic and statistical calculations, and for graphing.



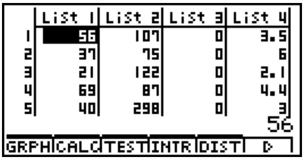
	List 1	List 2	List 3	List 4	List 5	List 20
1	56	1	107	3.5	4	0
2	37	2	75	6	0	0
3	21	4	122	2.1	0	0
4	69	8	87	4.4	2	0
5	40	16	298	3	0	0
6	48	32	48	6.8	3	0
7	93	64	338	2	9	0
8	30	128	49	8.7	0	0
⋮	⋮	⋮	⋮	⋮	⋮	⋮

3-1 Inputting and Editing a List

Enter the **STAT** Mode from the Main Menu to input data into a list and to manipulate list data.

• To input values one-by-one

Use the cursor keys to move the highlighting to the list name or cell you want to select.



	List 1	List 2	List 3	List 4
1	56	107	0	3.5
2	37	75	0	6
3	21	122	0	2.1
4	69	87	0	4.4
5	40	298	0	3

56

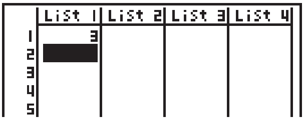
The screen automatically scrolls when the highlighting is located at either edge of the screen.

The following example is performed starting with the highlighting located at Cell 1 of List 1.

1. Input a value and press EXE to store it in the list.

   3 EXE

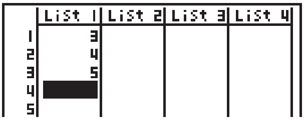
   - The highlighting automatically moves down to the next cell for input.



	List 1	List 2	List 3	List 4
1	3			
2				
3				
4				
5				

2. Input the value 4 in the second cell, and then input the result of 2 + 3 in the next cell.

   4 EXE 2 + 3 EXE



	List 1	List 2	List 3	List 4
1	3			
2	4			
3	5			
4				
5				

You can also input the result of an expression or a complex number into a cell.

You can input values up to 255 cells in a single list.

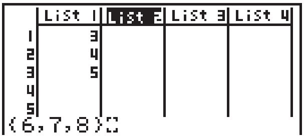
• To batch input a series of values

1. Use the cursor keys to move the highlighting to another list.

	List 1	List 2	List 3	List 4
1	3			

2. Press SHIFT ×({), and then input the values you want, pressing , between each one. Press SHIFT ÷(}) after inputting the final value.

SHIFT ×({) 6 , 7 , 8 SHIFT ÷(})

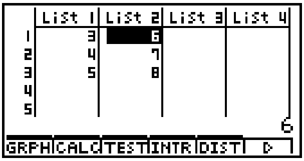


	List 1	List 2	List 3	List 4
1	3			
2	4			
3	5			
4				
5				

{6,7,8}

3. 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

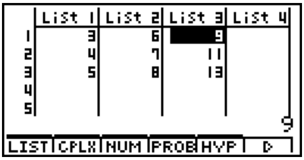
You can also use list names inside of a mathematical expression to input values into another cell. The following example shows how to add the values in each row in List 1 and List 2, and input the result into List 3.

1. Use the cursor keys to move the highlighting to the name of the list where you want the calculation results to be input.

	List 1	List 2	List 3	List 4
1	3	6		

2. Press OPTN and input the expression.

OPTN F1(LIST) 1(List) 1 +
OPTN F1(LIST) 1(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

You can also use SHIFT 1(List) in place of OPTN F1(LIST) 1(List).

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,}

Editing List Values

• To change a cell value

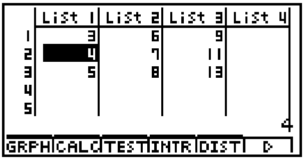
Use ◀ or ▶ to move the highlighting to the cell whose value you want to change. Input the new value and press EXE to replace the old data with the new one.

• To edit the contents of a cell

1. Use the cursor keys to move the highlighting to the cell whose contents you want to edit.
2. Press F6(▷)F2(EDIT) to display the contents of the cell at the bottom of the screen.
3. Make any changes in the data you want.

• To delete a cell

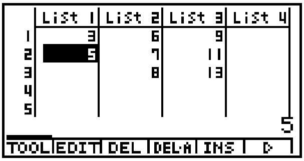
1. Use the cursor keys to move the highlighting to the cell you want to delete.



	List 1	List 2	List 3	List 4
1	3	6	9	
2	4	7	11	
3	5	8	13	
4				
5				

4

2. Press F6(▷)F3(DEL) to delete the selected cell and cause everything below it to be shifted up.



	List 1	List 2	List 3	List 4
1	3	6	9	
2	5	7	11	
3		8	13	
4				
5				

5

The cell delete operation does not affect cells in other lists. If the data in the list whose cell you delete is somehow related to the data in neighboring lists, deleting a cell can cause related values to become misaligned.

• To delete all cells in a list

Use the following procedure to delete all the data in a list.

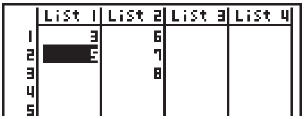
1. Use the cursor key to move the highlighting to any cell of the list whose data you want to delete.

2. Pressing F6(▷)F4(DEL•A) causes a confirmation message to appear.

3. Press EXE(Yes) to delete all the cells in the selected list or ESC(No) to abort the delete operation without deleting anything.

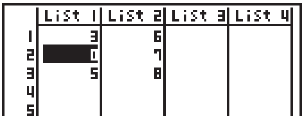
• To insert a new cell

1. Use the cursor keys to move the highlighting to the location where you want to insert the new cell.



	List 1	List 2	List 3	List 4
1	3	6		
2	5	7		
3		8		
4				
5				

2. Press F6(▷)F5(INS) to insert a new cell, which contains a value of 0, causing everything below it to be shifted down.



	List 1	List 2	List 3	List 4
1	3	6		
2	0	7		
3	5	8		
4				
5				

The cell insert operation does not affect cells in other lists. If the data in the list where you insert a cell is somehow related to the data in neighboring lists, inserting a cell can cause related values to become misaligned.

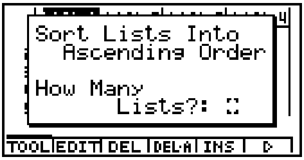
Sorting List Values

You can sort lists into either ascending or descending order. The highlighting can be located in any cell of the list.

• To sort a single list

Ascending order

1. While the lists are on the screen, press F6(▷)F1(TOOL)1(SortA).



Sort Lists Into
Ascending Order
How Many
Lists?:

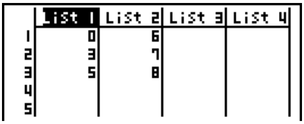
2. The prompt "How Many Lists?: " appears to ask how many lists you want to sort. Here we will input 1 to indicate we want to sort only one list.

1 EXE

Select List
List No:

3. In response to the "Select List List No: " prompt, input the number of the list you want to sort.

1 EXE



	List 1	List 2	List 3	List 4
1	0	6		
2	3	7		
3	5	8		
4				
5				

Descending order

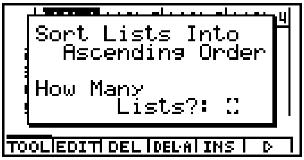
Use the same procedure as that for the ascending order sort. The only difference is that you should press 2(SortD) in place of 1(SortA).

• 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 F6 (▷) F1 (TOOL) 1 (SortA).



Sort Lists Into
Ascending Order
How Many
Lists?:

2. The prompt “How Many Lists?: ” 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

Select
Base List
List No:

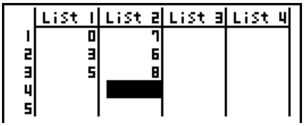
3. In response to the “Select Base List List No: ” prompt, input the number of the list you want to sort into ascending order. Here we will specify List 1.

1 EXE

Select
Second List
List No:

4. In response to the “Select Second List List No:” 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	0	7		
2	3	6		
3	5	8		
4				
5				

Descending order

Use the same procedure as that for the ascending order sort. The only difference is that you should press $\boxed{2}$(SortD) in place of $\boxed{1}$(SortA).

You can specify a value from 1 to 6 as the number of lists for sorting.

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).

Specifying a value of 0 for the number of lists causes all the lists in the file to be sorted. In this case you specify a base list on which all other lists in the file are sorted.

3-2 Manipulating List Data

List data can be used in arithmetic and function calculations. In addition, various list data manipulation functions make manipulation of list data quick and easy.

You can use list data manipulation functions in the **RUN•MAT**, **STAT**, **GRPH•TBL**, **EQUA** and **PRGM Modes**.

■ Accessing the List Data Manipulation Function Menu

All of the following examples are performed after entering the **RUN•MAT Mode**.

Press OPTN and then F1(LIST) to display the list data manipulation menu, which contains the following items.

- {**List**}/{**Dim**}/{**Seq**}/{**Min**}/{**Max**}/{**Mean**}/{**Median**}/{**Sum**}/{**Prod**}/{**Cuml**}/{**%**}/{**⊿List**}/{**Augmnt**}/{**Fill**}/{**L→Mat**}

Note that all closing parentheses at the end of the following operations can be omitted.

• To count the number of data items in a list **[OPTN]-[LIST]-[Dim]**

OPTN F1(LIST) 2(Dim) F1(LIST) 1(List) <list number 1-20> EXE

- The number of cells a list contains is its "dimension."

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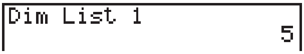
Example **To count the number of values in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) 2(Dim)
F1(LIST) 1(List) 1 EXE



```
Dim List 1
                5
```

• To create a list or matrix by specifying the number of data items

[OPTN]-[LIST]-[Dim]

Use the following procedure to specify the number of data in the assignment statement and create a list.

<number of data n> → OPTN F1(LIST) 2(Dim) F1(LIST) 1(List)
<list number 1-20> EXE

n = 1 ~ 255

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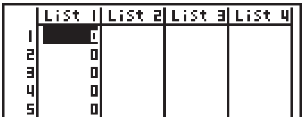
Example **To create five data items (each of which contains 0) in List 1**

AC 5 → OPTN F1(LIST) 2(Dim)
F1(LIST) 1(List) 1 EXE

You can view the newly created list by entering the STAT Mode.



	List 1	List 2	List 3	List 4
1	0			
2	0			
3	0			
4	0			
5	0			

Use the following procedure to specify the number of data rows and columns, and the matrix name in the assignment statement and create a matrix.

SHIFT × ({)<number of row m> , <number of column n> SHIFT ÷ (}) →
OPTN F1(LIST) 2(Dim) F2(MAT) 1(Mat) ALPHA <matrix name> EXE
m, n = 1 ~ 255, matrix name; A ~ Z

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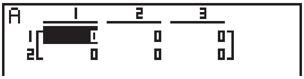
Example **To create a 2-row × 3-column matrix (each cell of which contains 0) in Matrix A**

AC SHIFT × ({) 2 , 3 SHIFT ÷ (}) →
OPTN F1(LIST) 2(Dim)
F2(MAT) 1(Mat) ALPHA X,θ,T (A) EXE

The following shows the new contents of Mat A.



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

• To replace all data items with the same value [OPTN]-[LIST]-[Fill]

OPTN F1(LIST) cos (Fill) <value> , F1(LIST) 1(List) <list number 1-20>) EXE

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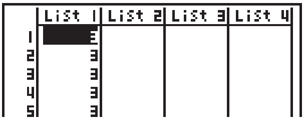
Example **To replace all data items in List 1 with the number 3**

AC OPTN F1(LIST) cos (Fill)
3 , F1(LIST) 1(List) 1) EXE

```
Fill(3,List 1)
                Done
```

The following shows the new contents of List 1.



	List 1	List 2	List 3	List 4
1	3			
2	3			
3	3			
4	3			
5	3			

• To generate a sequence of numbers [OPTN]-[LIST]-[Seq]

OPTN F1(LIST) 3(Seq) <expression> , <variable name> , <start value> , <end value> , <increment>) EXE

- The result of this operation is stored in ListAns Memory.

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Example **To input the number sequence 1^2, 6^2, 11^2, into a list, using the function $f(x) = X^2$. Use a starting value of 1, an ending value of 11, and an increment of 5**

AC OPTN F1(LIST) 3(Seq) X,θ,T x² ,
X,θ,T , 1 , 1 1 , 5) EXE


Ans
1 | 1
2 | 36
3 | 121

Specifying an ending value of 12, 13, 14, or 15 produces the same result as shown above, because all of them are less than the value produced by the next increment (16).

• To find the minimum value in a list [OPTN]-[LIST]-[Min]

OPTN F1(LIST) 4(Min) F1(LIST) 1(List) <list number 1-20>) EXE

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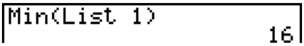
Example **To find the minimum value in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) 4(Min)
F1(LIST) 1(List) 1) EXE


Min(List 1)
16

• To find the maximum value in a list [OPTN]-[LIST]-[Max]

Use the same procedure as when finding the minimum value (Min), except press 5(Max) in place of 4(Min).

• To find which of two lists contains the smallest value **[OPTN]-[LIST]-[Min]**

OPTN F1(LIST) 4(Min) F1(LIST) 1(List) <list number 1-20>
, F1(LIST) 1 (List) <list number 1-20>) EXE

- The two lists must contain the same number of data items. If they don't, an error occurs.
- The result of this operation is stored in ListAns Memory.

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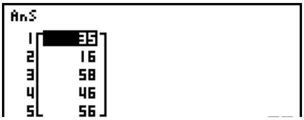
Example **To find whether List 1 (75, 16, 98, 46, 56) or List 2 (35, 59, 58, 72, 67) contains the smallest value**

OPTN F1(LIST) 4(Min)
F1(LIST) 1(List) 1 ,
F1(LIST) 1(List) 2) EXE



```
Ans
 1 [ 35 ]
 2   16
 3   58
 4   46
 5   56
```

• To find which of two lists contains the greatest value **[OPTN]-[LIST]-[Max]**

Use the same procedure as that for the smallest value, except press 5(Max) in place of 4(Min).

- The two lists must contain the same number of data items. If they don't, an error occurs.

• To calculate the mean of data items **[OPTN]-[LIST]-[Mean]**

OPTN F1(LIST) 6(Mean) F1(LIST) 1(List) <list number 1-20>) EXE

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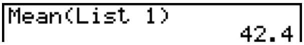
Example **To calculate the mean of data items in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) 6(Mean)
F1(LIST) 1(List) 1) EXE



```
Mean(List 1)
            42.4
```

• To calculate the mean of data items of specified frequency

[OPTN]-[LIST]-[Mean]

This procedure uses two lists: one that contains values and one that indicates the frequency (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 data items. If they don't, an error occurs.

OPTN F1(LIST) 6(Mean) F1(LIST) 1(List)<list number 1-20 (data)>
, F1(LIST) 1(List)<list number 1-20 (frequency)>) EXE

• • • • •

Example **To calculate the mean of data items in List 1 (36, 16, 58, 46, 56), whose frequency is indicated by List 2 (75, 89, 98, 72, 67)**

AC OPTN F1(LIST) 6(Mean)
F1(LIST) 1(List) 1 ,
F1(LIST) 1(List) 2) EXE

```
Mean(List 1,List 2)
          42.07481297
```

• To calculate the median of data items in a list **[OPTN]-[LIST]-[Med]**

OPTN F1(LIST) 7(Median) F1(LIST) 1(List)<list number 1-20>) EXE

• • • • •

Example **To calculate the median of data items in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) 7(Median)
F1(LIST) 1(List) 1) EXE

```
Median(List 1)
                   46
```

• To calculate the median of data items of specified frequency **[OPTN]-[LIST]-[Med]**

This procedure uses two lists: one that contains values and one that indicates the frequency (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 data items. If they don't, an error occurs.

OPTN F1(LIST) 7(Median) F1(LIST) 1(List) <list number 1-20 (data)>
, F1(LIST) 1(List) <list number 1-20 (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) 7(Median)
F1(LIST) 1(List) 1 ,
F1(LIST) 1(List) 2) EXE

```
Median(List 1,List 2)

                   46
```

• To calculate the sum of data items in a list **[OPTN]-[LIST]-[Sum]**

OPTN F1(LIST) 8(Sum) F1(LIST) 1(List)<list number 1-20> EXE

● ● ● ● ●

Example **To calculate the sum of data items in List 1 (36, 16, 58, 46, 56)**

AC OPTN F1(LIST) 8(Sum)
F1(LIST) 1(List) 1 EXE

```
Sum List 1
               212
```

• To calculate the product of values in a list **[OPTN]-[LIST]-[Prod]**

OPTN F1(LIST) 9(Prod) F1(LIST) 1(List)<list number 1-20> EXE

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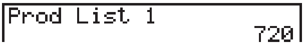
Example **To calculate the product of values in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1(LIST) 9(Prod)
F1(LIST) 1(List) 1 EXE



```
Prod List 1
               720
```

• To calculate the cumulative frequency of each data item

[OPTN]-[LIST]-[Cuml]

OPTN F1(LIST) X,θ,T(Cuml) F1(LIST) 1(List) <list number 1-20> EXE

- The result of this operation is stored in ListAns Memory.

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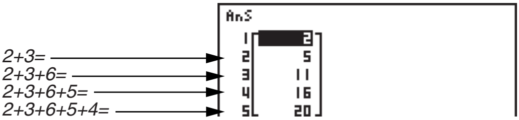
Example **To calculate the cumulative frequency of each data item in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1(LIST) X,θ,T(Cuml)
F1(LIST) 1(List) 1 EXE



```
Ans
 1[ 2]
 2  5
 3 11
 4 16
 5 20
```

• To calculate the percentage represented by each data item

[OPTN]-[LIST]-[%]

OPTN F1(LIST) log(%) F1(LIST) 1(List)<list number 1-20> EXE

- The above operation calculates what percentage of the list total is represented by each data item.
- The result of this operation is stored in ListAns Memory.

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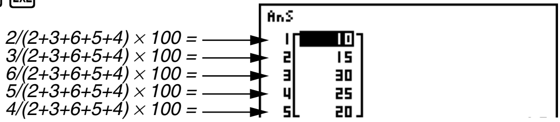
Example **To calculate the percentage represented by each data item in List 1 (2, 3, 6, 5, 4)**

AC OPTN F1(LIST) log(%)

F1(LIST) 1(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]
```

• To calculate the differences between neighboring data inside a list

[OPTN]-[LIST]-[⊿List]

OPTN F1(LIST) ln(⊿List)<list number 1-20> EXE

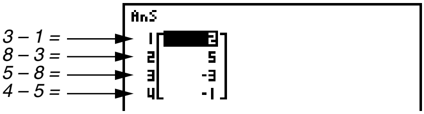
- The result of this operation is stored in ListAns memory.

● ● ● ● ●

Example **To calculate the difference between the data items in List 1 (1, 3, 8, 5, 4)**

AC OPTN F1(LIST) ln(⊿List)

1 EXE



3 – 1 =
8 – 3 =
5 – 8 =
4 – 5 =

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

You can specify the location of the new list (List 1 through List 20) with a statement like: ⊿ List 1 → List 2. You cannot specify another memory or ListAns as the destination of the ⊿ List operation. An error also occurs if you specify a ⊿ List as the destination of the results of another ⊿ List operation.

The number of cells in the new ⊿ List is one less than the number of cells in the original list.

An error occurs if you execute ⊿ List for a list that has no data or only one data item.

• To combine lists [OPTN]-[LIST]-[Augmnt]

- You can combine two different lists into a single list. The result of a list combination operation is stored in ListAns memory.

OPTN F1(LIST) sin(Augmnt) F1(LIST) 1(List) < list number 1-20 >
, F1(LIST) 1(List) < list number 1-20 >) EXE

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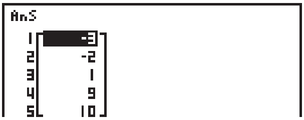
Example **To combine the List 1 (–3, –2) and List 2 (1, 9, 10)**

AC OPTN F1(LIST) sin(Augmnt)
F1(LIST) 1(List) 1 ,
F1(LIST) 1(List) 2) EXE



```
Ans
 1 [  -3 ]
 2 [  -2 ]
 3 [   1 ]
 4 [   9 ]
 5 [  10 ]
```

• To transfer list contents to Matrix Answer Memory [OPTN]-[LIST]-[L→Mat]

OPTN F1(LIST) tan(L→Mat) F1(LIST) 1(List) <list number 1-20>
, F1(LIST) 1(List) <list number 1-20>) EXE

- You can skip input F1(LIST) 1(List) in the part of the above operation.

Example: List → Mat (1, 2) EXE

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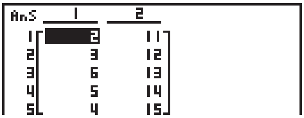
Example **To transfer the contents of List 1 (2, 3, 6, 5, 4) to column 1, and the contents of List 2 (11, 12, 13, 14, 15) to column 2 of Matrix Answer Memory**

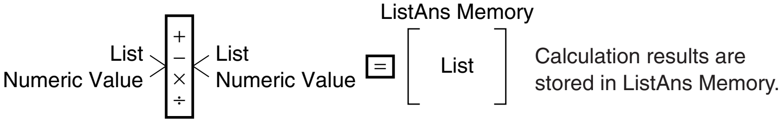
AC OPTN F1(LIST) tan(L→Mat)
F1(LIST) 1(List) 1 ,
F1(LIST) 1(List) 2) EXE



```
Ans     1      2
 1 [    2     11 ]
 2 [    3     12 ]
 3 [    6     13 ]
 4 [    5     14 ]
 5 [    4     15 ]
```

3-3 Arithmetic Calculations Using Lists

You can perform arithmetic calculations using two lists or one list and a numeric value.



Error Messages

- A calculation involving two lists performs the operation between corresponding cells. Because of this, an error occurs if the two lists do not have the same number of values (which means they have different "dimensions").
- An error occurs whenever an operation involving any two cells generates a mathematical error.

Inputting a List into a Calculation

There are two methods you can use to input a list into a calculation.

• To input a specific list by name

1. Press OPTN to display the first Operation Menu.

• This is the function key menu that appears in the **RUN•MAT Mode** when you press OPTN.

2. Press F1 (LIST) to display the List Data Manipulation Menu.

3. Press 1 (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 ,.

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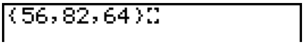
Example 1 To input the list: 56, 82, 64

SHIFT × ({) 5 6 , 8 2 ,
6 4 SHIFT ÷ (})


{56,82,64}

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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) 1 (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.

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Example 1 To assign the contents of List 3 to List 1

OPTN F1 (LIST) 1 (List) 3 → F1 (LIST) 1 (List) 1 EXE

In place of OPTN F1 (LIST) 1 (List) 3 operation in the above procedure, you could input SHIFT × ({) 4 1 , 6 5 , 2 2 SHIFT ÷ (}).

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Example 2 To assign the list in ListAns Memory to List 1

OPTN F1 (LIST) 1 (List) SHIFT (−) (Ans) → F1 (LIST) 1 (List) 1 EXE

• To recall the value in a specific list cell

You can recall the value in a specific list cell and use it in a calculation. Specify the cell number by enclosing it inside square brackets.

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Example To calculate the sine of the value stored in Cell 3 of List 2

sin OPTN F1(LIST) 1 (List) 2 SHIFT + ([ ) 3 SHIFT − ( ]) EXE

• To input a value into a specific list cell

You can input a value into a specific list cell inside a list. When you do, the value that was previously stored in the cell is replaced with the new value you input.

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Example To input the value 25 into Cell 2 of List 3

2 5 → OPTN F1(LIST) 1 (List) 3 SHIFT + ([ ) 2 SHIFT − ( ]) EXE

■ Recalling List Contents

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Example To recall the contents of List 1

OPTN F1(LIST) 1 (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

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Example To multiply the list contents in ListAns Memory by 36

OPTN F1(LIST) 1 (List) SHIFT (−) (Ans) × 3 6 EXE

- The operation OPTN F1(LIST) 1 (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 = List 1 X. If List 1 contains the values 1, 2, 3, this function will produces three graphs: Y = X, Y = 2X, Y = 3X.

There are certain limitations on using lists with graphing functions.

■ Inputting Scientific Calculations into a List

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.

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Example **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) 1(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 OPTN F1(LIST) 1(List) 3 operation in the above procedure, you could input SHIFT ×({) 4 1 , 6 5 , 2 2 SHIFT ÷(}).

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Example **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**$^{\text{List 2}}$

This creates a list with the results of 1^4, 2^5, 3^6.

OPTN F1(LIST) 1(List) 1 ^ F1(LIST) 1(List) 2 EXE

The resulting list $\begin{bmatrix} 1 \\ 32 \\ 729 \end{bmatrix}$ is stored in ListAns Memory.

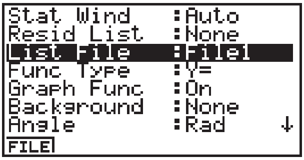
3-4 Switching Between List Files

You can store up to 20 lists (List 1 to List 20) in each file (File 1 to File 6). A simple operation lets you switch between list files.

• To switch between list files

1. From the Main Menu, enter the STAT Mode.

   Press CTRL F3 (SET UP) to display the STAT Mode SET UP screen.



```
Stat Wind    :Auto
Resid List   :None
List File    :File1
Func Type    :Y=
Graph Func   :On
Background   :None
Angle        :Rad    ↓
FILE
```

2. Press F1 (FILE) and then input the number of the list file you want to use.

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Example **To select File 3**

F1 (FILE) 3

```
Select File No.
   File[1~6]: 3
```

EXE

```
List File    :File3
```

All subsequent list operations are applied to the lists contained in the file you select (List File 3 in the above example).

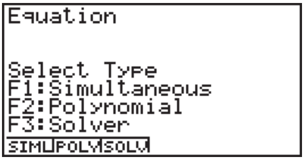
Chapter 4

Equation Calculations

Your graphic calculator can perform the following three types of calculations:

- Simultaneous linear equations
- Higher degree equations
- Solve calculations

From the Main Menu, enter the EQUA Mode.



Equation

Select Type
F1:Simultaneous
F2:Polynomial
F3:Solver

- {**SIML**} ... {linear equation with 2 to 30 unknowns}
- {**POLY**} ... {degree 2 to 30 equations}
- {**SOLV**} ... {solve calculation}

4-1 Simultaneous Linear Equations

Description

You can solve simultaneous linear equations with two to thirty unknowns.

- Simultaneous Linear Equation with Two Unknowns:

$$\begin{aligned} a_1x_1 + b_1x_2 &= c_1 \\ a_2x_1 + b_2x_2 &= c_2 \end{aligned}$$

- Simultaneous Linear Equation with Three Unknowns:

$$\begin{aligned} a_1x_1 + b_1x_2 + c_1x_3 &= d_1 \\ a_2x_1 + b_2x_2 + c_2x_3 &= d_2 \\ a_3x_1 + b_3x_2 + c_3x_3 &= d_3 \\ &\vdots \end{aligned}$$

Set Up

1. From the Main Menu, enter the EQUA Mode.

Execution

2. Select the SIML (simultaneous equation) Mode, and specify the number of unknowns (variables).
   You can specify from 2 to 30 unknowns. To specify more than six unknowns, press F6 (n) and then input a value.

3. Sequentially input the coefficients.

   The cell that is currently selected for input is highlighted. Each time you input a coefficient, the highlighting shifts in the sequence:

   $a_1 \rightarrow b_1 \rightarrow c_1 \rightarrow \ldots\ a_n \rightarrow b_n \rightarrow c_n \rightarrow$ (n = 2 to 30)

   You can also input fractions, complex numbers, and values assigned to variables as coefficients.

   You can cancel the value you are inputting for the current coefficient by pressing ESC at any time before you press EXE to store the coefficient value. This returns to the coefficient to what it was before you input anything. You can then input another value if you want.
   To change the value of a coefficient that you already stored by pressing EXE, move the cursor to the coefficient you want to edit. Next, input the value you want to change to or press F1 (EDIT).

   Pressing F3 (CLR) clears all coefficients to zero.

4. Solve the equations.

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

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

Procedure

① MENU EQUA

② F1(SIML)

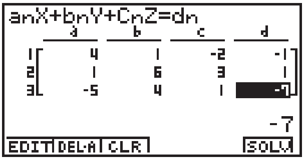
F2(3)

③ 4 EXE 1 EXE (–) 2 EXE (–) 1 EXE

1 EXE 6 EXE 3 EXE 1 EXE

(–) 5 EXE 4 EXE 1 EXE (–) 7 EXE

④ F6(SOLV)

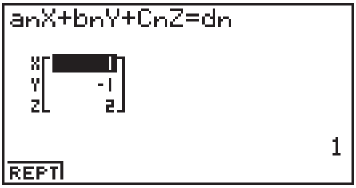


anX+bnY+CnZ=dn

	a	b	c	d
1	4	1	-2	-1
2	1	6	3	1
3	-5	4	1	-7

-7

Result Screen



anX+bnY+CnZ=dn

X	1
Y	-1
Z	2

1

Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and a 2-digit exponent.

Simultaneous linear equations are solved by inverting the matrix containing the coefficients of the equations. For example, the following shows the solution (x_1, x_2, x_3) of a simultaneous linear equation with three unknowns.

$$\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}^{-1} \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}$$

Because of this, precision is reduced as the value of the determinant approaches zero. Also, simultaneous equations with three or more unknowns may take a very long time to solve.

An error occurs if the calculator is unable to find a solution.

After calculation is complete, you can press F1 (REPT), change coefficient values, and then re-calculate.

4-2 Higher Degree Equations

Description

You can use this calculator to solve higher degree equations such as quadratic equations and cubic equations.

- Quadratic Equation:
  $ax^2 + bx + c = 0\ (a \neq 0)$
- Cubic Equation:
  $ax^3 + bx^2 + cx + d = 0(a \neq 0)$
  ⋮

Set Up

1. From the Main Menu, enter the EQUA Mode.

Execution

2. Select the POLY (higher degree equation) Mode, and specify the degree of the equation.
   You can specify a degree from 2 to 30. To specify a degree greater than three, press F3(n) and then input a value.
3. Sequentially input the coefficients.

   The cell that is currently selected for input is highlighted. Each time you input a coefficient, the highlighting shifts in the sequence:

   $a \rightarrow b \rightarrow c \rightarrow \ldots$

   You can also input fractions, complex numbers, and values assigned to variables as coefficients.

   You can cancel the value you are inputting for the current coefficient by pressing ESC at any time before you press EXE to store the coefficient value. This returns to the coefficient to what it was before you input anything. You can then input another value if you want.
   To change the value of a coefficient that you already stored by pressing EXE, move the cursor to the coefficient you want to edit. Next, input the value you want to change to or press F1(EDIT).

   Pressing F3(CLR) clears all coefficients to zero.
4. Solve the equations.

Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 10-digit mantissa and a 2-digit exponent.

High degree equations of third degree or higher may take a very long time to solve.

An error occurs if the calculator is unable to find a solution.

After calculation is complete, you can press F1(REPT), change coefficient values, and then re-calculate.

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Example **To solve the cubic equation**

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

Procedure

① MENU EQUA

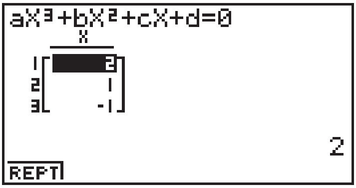
② F2(POLY)

F2(3)

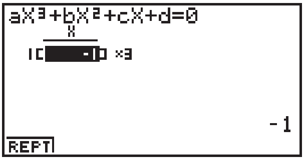
③ 1 EXE (–) 2 EXE (–) 1 EXE 2 EXE

④ F6(SOLV)

Result Screen



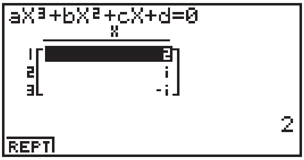
```
aX³+bX²+cX+d=0
      X
 1[      2]
 2[      1]
 3[     -1]
                 2
REPT
```



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

                -1
REPT
```

(Multiple Solutions)



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

(Complex Number Solution)

4-3 Solve Calculations

Description

The Solve Calculation Mode lets you determine the value of any variable in a formula without having to solve the equation.

Set Up

1. From the Main Menu, enter the EQUA Mode.

Execution

2. Select the SOLV (Solver) Mode, and input the equation as it is written.
   If you do not input an equals sign, the calculator assumes that the expression is to the left of the equals sign, and there is a zero to the right. [*1]
3. In the table of variables that appears on the display, input values for each variable.
   You can also specify values for Upper and Lower to define the upper and lower limits of the range of solutions. [*2]
4. Select the variable for which you want to solve to obtain the solution.
   "Lft" and "Rgt" indicate the left and right sides that are calculated using the solution.[*3]

[*1] An error occurs if you input more than one equals sign.

[*2] An error occurs if the solution falls outside the range you specify.

[*3] Solutions are approximated using Newton's method. Lft and Rgt values are displayed for confirmation, because Newton's method may produce results that are the real solution.
The closer the difference between the Lft and Rgt values is to zero, the lower degree of error in the result.

The message "Retry" appears on the display when the calculator judges that convergence is not sufficient for the displayed results.

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Example **An object thrown into the air at initial velocity V takes time T to reach height H. Use the following formula to solve for initial velocity V when H = 14 (meters), T = 2 (seconds) and gravitational acceleration is G = 9.8 (m/s^2).**

H = VT – 1/2 GT^2

Procedure

① MENU EQUA

② F3(SOLV)

ALPHA x^2(H) SHIFT •(=) ALPHA 2(V) ALPHA ÷(T) – (1 ÷ 2)

ALPHA $a^b/_c$(G) ALPHA ÷(T) x^2 EXE

③ 1 4 EXE(H = 14)

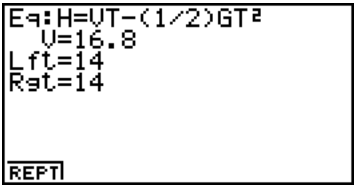
0 EXE(V = 0)

2 EXE(T = 2)

9 • 8 EXE(G = 9.8)

④ Press ▲ to highlight V = 0, and then press F6(SOLV).

Result Screen



```
Eq:H=VT-(1/2)GT²
  V=16.8
Lft=14
Rgt=14
```

4-4 What to Do When an Error Occurs

• Error during coefficient value input

Press the ESC 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 ESC key to clear the error and display the coefficient. Try inputting values for the coefficients again.

■ Clearing Equation Memories

1. Enter the equation calculation mode (SIML or POLY) you want to use and perform the function key operation required for that mode.
   - In the case of the SIML Mode (F1), use number keys to specify the number of unknowns.
   - In the case of the POLY Mode (F2), use number keys to specify the degree of the polynomial.
   - If you pressed F3(SOLV), advance directly to step 2.
2. Press F2(DEL•A).
3. Press EXE(Yes) to delete the applicable equation memories or ESC(No) to abort the operation without deleting anything.

Chapter 5

Graphing

Sections 5-1 and 5-2 of this chapter provide basic information you need to know in order to draw a graph. The remaining sections describe more advanced graphing features and functions.

Select the icon in the Main Menu that suits the type of graph you want to draw or the type of table you want to generate.

- **GRPH • TBL** … General function graphing or number table generation
- **CONICS** … Conic section graphing (5-1-5 ~ 5-1-6, 5-11-17~5-11-21)
- **RUN • MAT** … Manual graphing (5-6-1 ~ 5-6-4)
- **DYNA** … Dynamic Graph (5-8-1 ~ 5-8-6)
- **RECUR** … Recursion graphing or number table generation (5-9-1 ~ 5-9-8)

5-1 Sample Graphs

How to draw a simple graph (1)

Description

To draw a graph, simply input the applicable function.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Input the function you want to graph.
   Here you would use the V-Window to specify the range and other parameters of the graph. See 5-2-1.
3. Draw the graph.

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Example **To graph $y = 3x^2$**

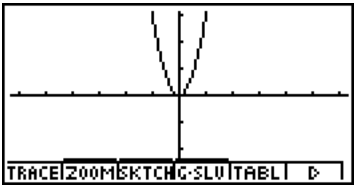
Procedure

① MENU GRPH • TBL

② 3 X,θ,T x^2 EXE

③ F5(DRAW) (or EXE)

Result Screen



How to draw a simple graph (2)

Description

You can store up to 20 functions in memory and then select the one you want for graphing.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Specify the function type and input the function whose graph you want to draw.

   You can use the GRPH • TBL Mode to draw a graph for the following types of expressions: rectangular coordinate expression, polar coordinate expression, parametric function, X = constant expression, inequality.

   [F3] (TYPE) [1] (Y =) ... rectangular coordinates
   [2] (r =) ... polar coordinates
   [3] (Param) ... parametric function
   [4] (X = c) ... X = constant function
   [5] (INEQUA) [1] (Y>)~ [4] (Y≦) ... inequality
   [6] (CONV) [1] (▶Y=)~ [5] (▶Y≦) ... changes the function type

   Repeat this step as many times as required to input all of the functions you want.

   Next you should specify which of the functions among those that are stored in memory you want to graph (see 5-3-6). If you do not select specific functions here, the graph operation will draw graphs of all the functions currently stored in memory.

3. Draw the graph.

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Example **Input the functions shown below and draw their graphs**
Y1 = $2x^2 - 3$, $r2 = 3\sin 2\theta$

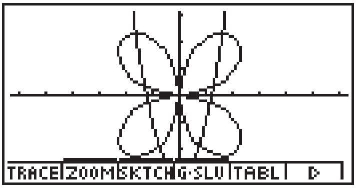
Procedure

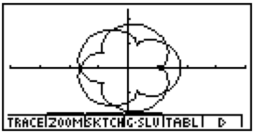
① MENU GRPH • TBL

② F3 (TYPE) 1 (Y=) 2 X,θ,T x^2 − 3 EXE
F3 (TYPE) 2 (r=) 3 sin 2 X,θ,T EXE

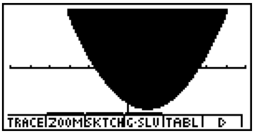
③ F5 (DRAW)

Result Screen

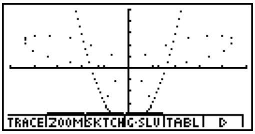




(Param)



(INEQUA)



(Plot)

How to draw a simple graph (3)

Description

Use the following procedure to graph the function of a parabola, circle, ellipse, or hyperbola.

Set Up

1. From the Main Menu, enter the CONICS Mode.

Execution

2. Use the cursor ▲ ▼ keys to specify one of the function type as follows.

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	$\frac{(X - H)^2}{A^2} - \frac{(Y - K)^2}{B^2} = 1$ $\frac{(Y - K)^2}{A^2} - \frac{(X - H)^2}{B^2} = 1$

3. Input values for the required variables.
4. Graph the function.

● ● ● ● ●

Example **Graph the circle $(X-1)^2 + (Y-1)^2 = 2^2$**

Procedure

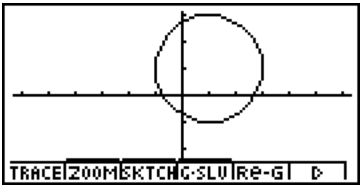
① MENU CONICS

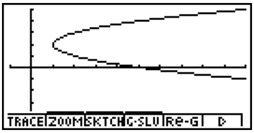
② ▼ ▼ ▼ ▼ EXE

③ 1 EXE 1 EXE 2 EXE

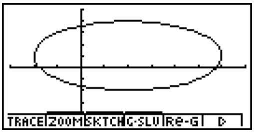
④ F6 (DRAW)

Result Screen

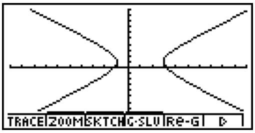




(Parabola)



(Ellipse)



(Hyperbola)

5-2 Controlling What Appears on a Graph Screen

■ V-Window (View 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 V-Window parameters you want to use before graphing.

• To make V-Window settings

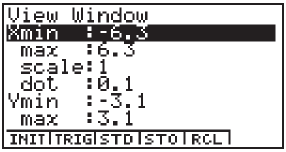
1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press SHIFT OPTN (V-Window) to display the V-Window setting screen.

Rectangular coordinate parameter

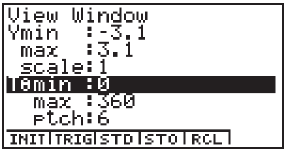
Xmin … Minimum *x*-axis value
Xmax … Maximum *x*-axis value
Xscale … Spacing of *x*-axis increments
Xdot … Value that corresponds to one *x*-axis dot
Ymin … Minimum *y*-axis value
Ymax … Maximum *y*-axis value
Yscale … Spacing of *y*-axis increments

Polar coordinate parameter

Tθ min ... T, θ minimum values
Tθ max ... T, θ maximum values
Tθ ptch ... T, θ pitch



```
View Window
Xmin  :-6.3
 max  :6.3
 scale:1
 dot  :0.1
Ymin  :-3.1
 max  :3.1
```



```
View Window
Ymin  :-3.1
 max  :3.1
 scale:1
Tθmin :0
   max :360
   ptch:6
```

3. Press ▼ to move the highlighting and input an appropriate value for each parameter, pressing EXE after each.
   - {**INIT**}/{**TRIG**}/{**STD**} … V-Window {initial settings}/{initial settings using specified angle unit}/{standardized settings}
   - {**STO**}/{**RCL**} … V-Window setting {store}/{recall}

After settings are the way you want them, press ESC or SHIFT ESC (QUIT) to exit the V-Window setting screen.[*1]

[*1] Pressing EXE without inputting anything while ■ is displayed exits the View Window setting screen.

• V-Window Setting Precautions

- Inputting zero for Tθ ptch causes an error.
- Any illegal input (out of range value, negative sign without a value, etc.) causes an error.
- An error occurs when Xmax is less than Xmin, or Ymax is less than Ymin. When Tθ max is less than Tθ min, Tθ ptch becomes negative.
- You can input expressions (such as 2π) as V-Window parameters.
- When the V-Window setting produces an axis that does not fit on the display, the scale of the axis is indicated on the edge of the display closest to the origin.
- Changing the V-Window settings clears the graph currently on the display and replaces it with the new axes only.
- Changing the Xmin or Xmax value causes the Xdot value to be adjusted automatically. Changing the Xdot value causes the Xmax value to be adjusted automatically.
- A polar coordinate (r =) or parametric graph will appear coarse if the settings you make in the V-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.
- The following is the input range for V-Window parameters.

  –9.999999999E 97 to 9.999999999E 97

Initializing and Standardizing the V-Window

• To initialize the V-Window

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press SHIFT OPTN (V-Window).
   This displays the V-Window setting screen.
3. Press F1 (INIT) to initialize the V-Window.

Xmin = –6.3, Xmax = 6.3, Xscale = 1 Xdot = 0.1
Ymin = –3.1, Ymax = 3.1, Yscale = 1
Tθ min = 0, Tθ max = 2π (rad), Tθ ptch = 2π /60 (rad)

• To initialize the V-Window in accordance with an angle unit

In step 3 of the procedure under "To initialize the V-Window" above, press F2 (TRIG) to initialize the V-Window in accordance with an angle unit.

Xmin = –3π (rad), Xmax = 3π (rad), Xscale = π /2 (rad), Xdot = π /21 (rad),
Ymin = –1.6, Ymax = 1.6, Yscale = 0.5

• To standardize the V-Window

The following are the standard V-Window settings of this calculator.

Xmin = –10, Xmax = 10, Xscale = 1, Xdot = 0.15873015,
Ymin = –10, Ymax = 10, Yscale = 1,
Tθ min = 0, Tθ max = 2π (rad), Tθ ptch = 2π /60 (rad)

In step 3 of the procedure under "To initialize the V-Window" above, press F3 (STD) to standardize V-Window settings in accordance with the above.

Initialization and standardization cause Tθ min, Tθ max, Tθ ptch values to change automatically in accordance with the current angle unit setting as shown below.

Deg Mode:
Tθ min = 0, Tθ max = 360, Tθ ptch = 6

Gra Mode:
Tθ min = 0, Tθ max = 400, Tθ ptch = 400/60

■ V-Window Memory

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

• To store V-Window settings

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press SHIFT OPTN (V-Window) to display the V-Window setting screen, and input the values you want.
3. Press F4 (STO) to display the pop-up window.
4. Press a number key to specify the V-Window memory where you want to save the settings, and then press EXE. Pressing 1 EXE stores the settings in V-Window Memory 1 (V-Win1).

• To recall V-Window memory settings

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Press SHIFT OPTN (V-Window) to display the V-Window setting screen.
3. Press F5 (RCL) to display the pop-up window.
4. Press a number key to specify the V-Window memory number for the settings you want to recall, and then press EXE. Pressing 1 EXE recalls the settings in V-Window Memory 1 (V-Win1).

Storing V-Window settings to a memory that already contains setting data replaces the previous data with the new settings.

Recalling settings causes the current V-Window settings to be replaced with those recalled from memory.

Specifying the Graph Range

Description

You can define a range (start point, end point) for a function before graphing it.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make V-Window settings.

Execution

3. Specify the function type and input the function. The following is the syntax for function input.

   Function , SHIFT + ([ )Start Point , End Point SHIFT − ( ])
4. Draw the graph.

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Example **Graph $y = x^2 + 3x - 2$ within the range $-2 \leqq x \leqq 4$**

Use the following V-Window settings.

Xmin = –3, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 30, Yscale = 5

Procedure

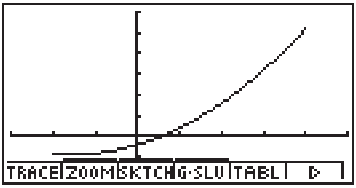
① MENU GRPH • TBL

② SHIFT OPTN (V-Window) (–) 3 EXE 5 EXE 1 EXE ▼
(–) 1 0 EXE 3 0 EXE 5 EXE ESC

③ F3 (TYPE) 1 (Y=) X,θ,T x^2 + 3 X,θ,T − 2 ,
SHIFT + ([ ) (–) 2 , 4 SHIFT − ( ]) EXE

④ F5 (DRAW)

Result Screen



You can specify a range when graphing rectangular expressions, polar expressions, parametric functions, and inequalities.

■ Zoom

Description

This function lets you enlarge and reduce the graph on the screen.

Set Up

1. Draw the graph.

Execution

2. Specify the zoom type.

F2 (ZOOM) 1 (Box) ... Box zoom

Draw a box around a display area, and that area is enlarged to fill the entire screen.

2 (Factor)

3 (In)/ 4 (Out) ... Factor zoom

The graph is enlarged or reduced in accordance with the factor you specify, centered on the current pointer location.

5 (Auto) ... Auto zoom

V-Window y-axis settings are automatically adjusted so the graph fills the screen along the y-axis.

6 (Orig) ... Original size

Returns the graph to its original size following a zoom operation.

7 (Square) ... Graph correction

V-Window x-axis values are corrected so they are identical to the y-axis values.

8 (Rnd) ... Coordinate rounding

Rounds the coordinate values at the current pointer location.

9 (Intg) ... Integer

Each dot is given a width of 1, which makes coordinate values integers.

X,θ,T (Pre) ... Previous

V-Window parameters are returned to what they were prior to the last zoom operation.

log (QUICK) ... Quick zoom

Redraws the graph in accordance with the settings stored in a selected V-Window memory.

Box zoom range specification

3. Use the cursor keys to move the pointer (✛) in the center of the screen to the location where you want one corner of the box to be, and then press EXE.
4. Use the cursor keys to move the pointer. This causes a box to appear on the screen. Move the cursor until the area you want to enlarge is enclosed in the box, and then press EXE to enlarge it.

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Example **Graph $y = (x + 5)(x + 4)(x + 3)$, and then perform a box zoom.**

Use the following V-Window settings.

Xmin = –8, Xmax = 8, Xscale = 2

Ymin = –4, Ymax = 2, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 8 EXE 8 EXE 2 EXE ▼

(–) 4 EXE 2 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) (X,θ,T + 5) (X,θ,T + 4)

(X,θ,T + 3) EXE

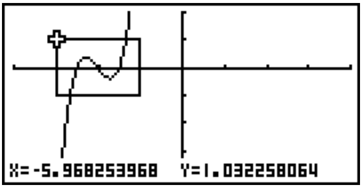
F5 (DRAW)

② F2 (ZOOM) 1 (Box)

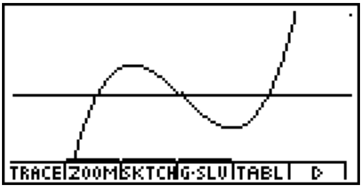
③ ◀ ~ ◀ EXE

④ ◀ ~ ◀ , ▲ ~ ▲ EXE

Result Screen



X=-5.968253968 Y=1.032258064



You must specify two different points for box zoom, and the two points cannot be on a straight line vertically or horizontally from each other.

Factor Zoom

Description

With factor zoom, you can zoom in or out, centered on the current cursor position.

Set Up

1. Draw the graph.

Execution

2. Press F2(ZOOM) 2(Factor) to open a pop-up window for specifying the x-axis and y-axis zoom factor. Input the values you want and then press ESC.
3. Press F2(ZOOM) 3(In) to enlarge the graph, or F2(ZOOM) 4(Out) to reduce it. The graph is enlarged or reduced centered on the current pointer location.
4. Use the cursor keys to move the cursor to the point upon which you want the zoom operation to be centered, and then press EXE to zoom.

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Example **Enlarge the graphs of the two expressions shown below five times on both the x-and y-axis to see if they are tangent.**
Y1 = $(x + 4)(x + 1)(x - 3)$, Y2 = $3x + 22$

Use the following V-Window settings.

Xmin = –8, Xmax = 8, Xscale = 1
Ymin = –30, Ymax = 30, Yscale = 5

Procedure

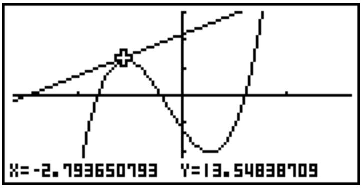
① MENU GRPH • TBL
SHIFT OPTN (V-Window) (–) 8 EXE 8 EXE 1 EXE ▼
(–) 3 0 EXE 3 0 EXE 5 EXE ESC
F3 (TYPE) 1 (Y=) (X,θ,T + 4) (X,θ,T + 1)
(X,θ,T – 3) EXE
3 X,θ,T + 2 2 EXE
F5 (DRAW)

② F2 (ZOOM) 2 (Factor) 5 EXE 5 EXE ESC

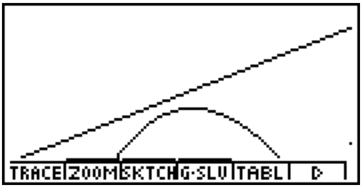
③ F2 (ZOOM) 3 (In)

④ ▲~▲, ◀~◀ EXE

Result Screen



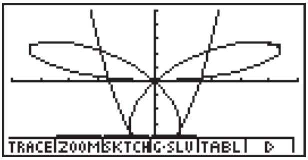
X=-2.793650793 Y=13.54838709

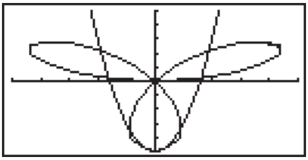


You can repeat factor zoom to enlarge or reduce a graph even further.

■ Turning Function Menu Display On and Off

Press CTRL 0 to toggle display of the menu at the bottom of the screen on and off.



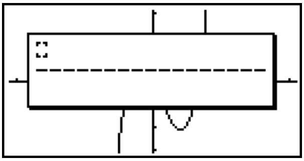


Turning off the function menu display makes it possible to view part of a graph hidden behind it. When you are using the trace function or other functions during which the function menu is normally not displayed, you can turn on the menu display to execute a menu command.

If a pull-up menu is open when you press CTRL 0 to turn off menu display, the pull-up menu remains on the screen.

About the Calc Window

Pressing CTRL F4(CAT/CAL) while a graph or number table is on the display opens the Calc Window. You can use the Calc Window to perform calculations with values obtained from graph analysis, or to change the value assigned to variable A in Y = AX and other expressions and then redraw the graph.



Press ESC to close the Calc Window.

After using the Calc Window to change the value of a variable connected with a graph or table, be sure to always execute Re-G (re-graph) or Re-T (re-calculate table). Doing so ensures that the displayed graph or table is current.

Calc Window cannot be used in the RUN • MAT Mode while a program is running, or in combination with Dynamic Graph.

Calc Window cannot be used in combination with V-Window or the table range setting screen.

Complex number calculations cannot be performed on the Calc Window.

5-3 Drawing a Graph

You can store up to 20 functions in memory. Functions in memory can be edited, recalled, and graphed.

Specifying the Graph Type

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

1. While the Graph function list is on the display, press F6(▷)F3(TYPE) to display the graph type menu, which contains the following items.
    - {**Y=**}/{**r=**}/{**Param**}/{**X=c**} ... {rectangular coordinate}/{polar coordinate}/{parametric}/{X=constant}[*1] graph
    - {**INEQUA**}
        - {**Y>**}/{**Y<**}/{**Y≥**}/{**Y≤**} ... {Y>$f(x)$}/{Y<$f(x)$}/{Y≧$f(x)$}/{Y≦$f(x)$} inequality graph
    - {**CONV**}
        - {**►Y=**}/{**►Y>**}/{**►Y<**}/{**►Y≥**}/{**►Y≤**} ... changes the function type
2. Press the number key that corresponds to the graph type you want to specify.

Storing Graph Functions

• To store a rectangular coordinate function (Y =) [*2]

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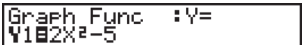
Example **To store the following expression in memory area Y1 : $y = 2x^2 - 5$**

F3(TYPE) 1 (Y =) (Specifies rectangular coordinate expression.)

2 X,θ,T x² − 5 (Inputs expression.)

EXE (Stores expression.)



```
Graph Func   :Y=
Y1=2X²-5
```

• To store a polar coordinate function (r =) [*2]

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Example **To store the following expression in memory area r2 : $r = 5\sin 3\theta$**

F3(TYPE) 2 (r =) (Specifies polar coordinate expression.)

5 sin 3 X,θ,T (Inputs expression.)

EXE (Stores expression.)

[*1] Attempting to draw a graph for an expression in which X is input for an X = constant expression results in an error.

[*2] A function cannot be stored into a memory area that already contains a function of a different type from the one you are trying to store. Select a memory area that contains a function that is the same type as the one you are storing, or delete the function in the memory area to which you are trying to store.

• To store a parametric function [1]

●●●●●

Example **To store the following functions in memory areas Xt3 and Yt3 :**

$x = 3 \sin T$

$y = 3 \cos T$

F3 (TYPE) 3 (Param) (Specifies parametric expression.)

3 sin X,θ,T EXE (Inputs and stores x expression.)

3 cos X,θ,T EXE (Inputs and stores y expression.)

• To store an X = constant expression [2]

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Example **To store the following expression in memory area X4 :**

X = 3

F3 (TYPE) 4 (X = c) (Specifies X = constant expression.)

3 (Inputs expression.)

EXE (Stores expression.)

- Inputting X, Y, T, r, or θ for the constant in the above procedures causes an error.

• To store an inequality [2]

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Example **To store the following inequality in memory area Y5 :**

$y > x^2 - 2x - 6$

F3 (TYPE) 5 (INEQUA) 1 (Y>) (Specifies an inequality.)

X,θ,T x^2 − 2 X,θ,T − 6 (Inputs expression.)

EXE (Stores expression.)

---

[1] 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.

[2] A function cannot be stored into a memory area that already contains a function of a different type from the one you are trying to store. Select a memory area that contains a function that is the same type as the one you are storing, or delete the function in the memory area to which you are trying to store.

• To create a composite function

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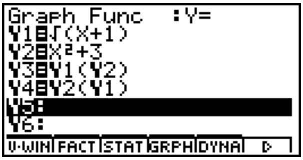
Example **To register the following functions as a composite function:**
$Y1=\sqrt{(X+1)}$, $Y2=X^2+3$
Assign $Y1\circ Y2$ to Y3, and $Y2\circ Y1$ to Y4.
$(Y1\circ Y2=\sqrt{((x^2+3)+1)}=\sqrt{(x^2+4)}$ $\quad Y2\circ Y1=(\sqrt{(X+1)})^2+3=X+4$ $(X\geqq-1))$

F3 (TYPE) 1 (Y=)
VARS F4 (GRPH) 1 (Yn) 1
(F1 (Yn) 2) EXE
F4 (GRPH) 1 (Yn) 2
(F1 (Yn) 1) EXE



```
Graph Func   :Y=
Y1■√(X+1)
Y2■X²+3
Y3■Y1(Y2)
Y4■Y2(Y1)
Y5:
Y6:
```

• A composite function can consist of up to five functions.

• To assign values to the coefficients and variables of a graph function

After you combine functions or equations into a composite function, you can assign values to the coefficients and variables of the expression and draw a graph.

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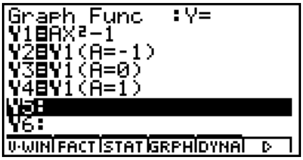
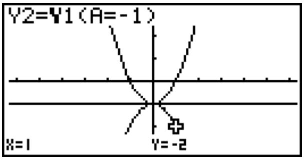
Example **Assign the values –1, 0, and 1 to the expression $Y=AX^2-1$, which is in memory area A**

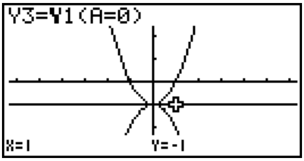
F3 (TYPE) 1 (Y=)
ALPHA X,θ,T (A) X,θ,T x^2 − 1 EXE
VARS F4 (GRPH) 1 (Yn) 1
(ALPHA X,θ,T (A) SHIFT • (=) (–) 1) EXE
F4 (GRPH) 1 (Yn) 1
(ALPHA X,θ,T (A) SHIFT • (=) 0) EXE
F4 (GRPH) 1 (Yn) 1
(ALPHA X,θ,T (A) SHIFT • (=) 1) EXE

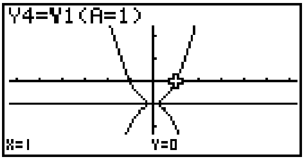


```
Graph Func   :Y=
Y1■AX²-1
Y2■Y1(A=-1)
Y3■Y1(A=0)
Y4■Y1(A=1)
Y5:
Y6:
```

▲ ▲ ▲ ▲ ESC F1(SEL) F5(DRAW)







The above three screens are produced using the Trace function.
See “5-11 Function Analysis” for more information.

- If you do not specify a variable name (variable A in the above key operation), the calculator automatically uses one of the default variables listed below. Note that the default variable used depends on the memory area type where you are storing the graph function.

Memory Area Type	Default Variable
Yn	X
rn	θ
Xtn	T
Ytn	T
fn	X

● ● ● ● ●

Example Y1 (3) and Y1 (X = 3) are identical values.

- You can also use Dynamic Graph for a look at how changes in coefficients alter the appearance of a graph. See “5-8 Dynamic Graphing” for more information.

Editing and Deleting Functions

• To edit a function in memory

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Example **To change the expression in memory area Y1 from $y = 2x^2 - 5$ to $y = 2x^2 - 3$**

▶ (Displays cursor.)

▶ ▶ ▶ ▶ DEL 3 (Changes contents.)

EXE (Stores new graph function.)

• To change the type of a function*1

1. While the Graph function list is on the display, press ▲ or ▼ to move the highlighting to the area that contains the function whose type you want to change.
2. Press F3 (TYPE) 6 (CONV).
3. Select the function type you want to change to.

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Example **To change the function in memory area Y1 from $y = 2x^2 - 3$ to $y < 2x^2 - 3$**

F3 (TYPE) 6 (CONV) 3 (►Y<) (Changes the function type to "Y<".)

• To delete a function

1. While the Graph function list is on the display, press ▲ or ▼ to move the highlighting to the area that contains the function you want to delete.
2. Press F2 (DEL) or DEL.
3. Press EXE (Yes) to delete the function or ESC (No) to abort the procedure without deleting anything.

---

[1] The function type can be changed for rectangular coordinate functions and inequalities only.

Parametric functions come in pairs (Xt and Yt). When editing a parametric function, clear the graph functions and re-input from the beginning.

Selecting Functions for Graphing

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

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Example **To select the following functions for drawing :**
Y1 = $2x^2 - 5$, $r2 = 5\sin 3\theta$

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

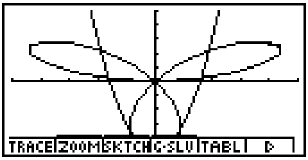
Ymin = –5, Ymax = 5, Yscale = 1

Tθ min = 0, Tθ max = π, Tθ ptch = $2\pi / 60$

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

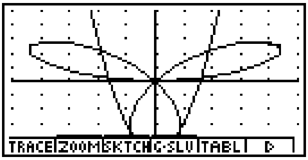
F1(SEL) (Specifies non-draw.)

F5(DRAW) or EXE (Draws the graphs.)



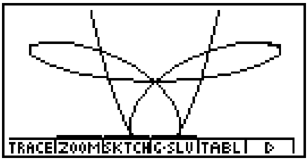
- Each press of F1(SEL) toggles a graph between draw and non-draw.
- Pressing CTRL F5(G↔T) or ESC returns to the Graph function list.
- You can use the SET UP screen settings to alter the appearance of the graph screen as shown below.
- Grid: On (Axes: On Label: Off)

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



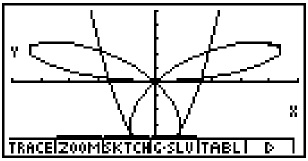
- Axes: Off (Label: Off Grid: Off)

  This setting clears the axis lines from the display.



- Label: On (Axes: On Grid: Off)

  This setting displays labels for the x- and y-axes.



Graph Memory

Graph memory lets you store up to 20 sets of graph function data and recall it later when you need it.

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

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

• To store graph functions in graph memory

1. Press F4(GMEM) 1(Store) to display the pop-up window.
2. Press a number key to specify the Graph memory where you want to save the graph function, and then press EXE. Pressing 1 EXE stores the graph function to Graph Memory 1 (G-Mem1).
   - There are 20 graph memories numbered G-Mem1 to G-Mem20.

• To recall a graph function

1. Press F4(GMEM) 2(Recall) to display the pop-up window.
2. Press a number key to specify the Graph memory for the function you want to recall, and then press EXE. Pressing 1 EXE recalls the graph function in Graph Memory 1 (G-Mem1).

Storing a function in a memory area that already contains a function replaces the existing function with the new one.

If the data exceeds the calculator's remaining memory capacity, an error occurs.

Recalling data from graph memory causes any data currently on the Graph function list to be deleted.

5-4 Storing a Graph in Picture Memory

You can save up to 20 graphic images 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

1. After graphing in GRPH•TBL Mode, press F6(▷)F1(PICT)1(Store) to display the pop-up window.
2. Press a number key to specify the Picture memory where you want to save the picture, and then press EXE. Pressing 1 EXE stores the picture function to Picture Memory 1 (Pict 1).

- There are 20 picture memories numbered Pict 1 to Pict 20.

• To recall a stored graph

1. After graphing in GRPH•TBL Mode, press F6(▷)F1(PICT)2(Recall) to display the pop-up window.
2. Press a number key to specify the Picture memory for the picture you want to recall, and then press EXE. Pressing 1 EXE recalls the picture function in Picture Memory 1 (Pict 1).

Storing a graphic image in a memory area that already contains a graphic image replaces the existing graphic image with the new one.

A dual Graph screen or any other type of graph that uses a split screen cannot be saved in picture memory.

5-5 Drawing Two Graphs on the Same Screen

■ Copying the Graph to the Sub-screen

Description

Dual Graph lets you split the screen into two parts. Then you can graph two different functions in each for comparison, or draw a normal size graph on one side and its enlarged version on the other side. This makes Dual Graph a powerful graph analysis tool.

With Dual Graph, the left side of the screen is called the “main screen,” while the right side is called the “sub-screen.”

- **Main Screen**
  The graph in the main screen is actually drawn from a function.
- **Sub-screen**
  The graph on the sub-screen is produced by copying or zooming the main screen graph. You can even make different V-Window settings for the sub-screen and main screen.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, select G+G for Dual Screen.
3. Make V-Window settings for the main screen.

   Press F6(RIGHT) to display the sub-graph settings screen. Pressing F6(LEFT) returns to the main screen setting screen.

Execution

4. Store the function, and draw the graph in the main screen.
5. Perform the Dual Graph operation you want.

   F4(COPY) ... Duplicates the main screen graph in the sub-screen

   F5(SWAP) ... Swaps the main screen contents and sub-screen contents

• • • • •

Example **Graph $y = x(x + 1)(x - 1)$ in the main screen and sub-screen.**

Use the following V-Window settings.

(Main Screen)

Xmin = –2, Xmax = 2, Xscale = 0.5
Ymin = –2, Ymax = 2, Yscale = 1

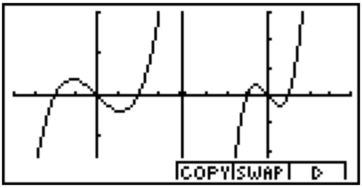
(Sub-screen)

Xmin = –4, Xmax = 4, Xscale = 1
Ymin = –3, Ymax = 3, Yscale = 1

Procedure

① MENU GRPH • TBL
② CTRL F3(SET UP) ▼ ▼ ▼ F2(G+G) ESC
③ SHIFT OPTN(V-Window) (–) 2 EXE 2 EXE 0 • 5 EXE ▼
(–) 2 EXE 2 EXE 1 EXE
F6(RIGHT) (–) 4 EXE 4 EXE 1 EXE ▼
(–) 3 EXE 3 EXE 1 EXE ESC
④ F3(TYPE) 1(Y=) X,θ,T (X,θ,T + 1) (X,θ,T – 1) EXE
F5(DRAW)
⑤ F6(▷) F4(COPY)

Result Screen



Graphing Two Different Functions

Description

Use the following procedure to graph different functions in the main screen and sub-screen.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, select G+G for Dual Screen.
3. Make V-Window settings for the main screen.

   Press F6 (RIGHT) to display the sub-graph settings screen. Pressing F6 (LEFT) returns to the main screen setting screen.

Execution

4. Store the functions for the main screen and sub-screen.
5. Select the function of the graph that you want to eventually have in the sub-screen.
6. Draw the graph in the main screen.
7. Swap the main screen and sub-screen contents.
8. Return to the function screen.
9. Select the function of the next graph you want in the main screen.
10. Draw the graph in the main screen.

● ● ● ● ●

Example **Graph $y = x(x + 1)(x - 1)$ in the main screen, and $y = 2x^2 - 3$ in the sub-screen.**

Use the following V-Window settings.

(Main Screen)

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

(Sub-screen)

Xmin = –2,	**Xmax = 2,**	**Xscale = 0.5**
Ymin = –2,	**Ymax = 2,**	**Yscale = 1**

Procedure

① MENU GRPH • TBL

② CTRL F3(SET UP) ▼ ▼ ▼ F2(G+G) ESC

③ SHIFT OPTN(V-Window) (–) 4 EXE 4 EXE 1 EXE ▼
(–) 5 EXE 5 EXE 1 EXE
F6(RIGHT) (–) 2 EXE 2 EXE 0 • 5 EXE ▼
(–) 2 EXE 2 EXE 1 EXE ESC

④ F3(TYPE) 1(Y=) X,θ,T (X,θ,T + 1) (X,θ,T – 1) EXE
2 X,θ,T x^2 – 3 EXE

⑤ ▲ ▲ F1(SEL)

⑥ F5(DRAW)

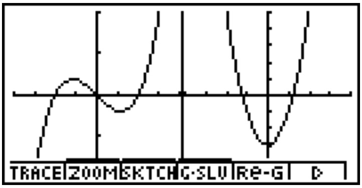
⑦ F6(▷) F5(SWAP)

⑧ ESC

⑨ F1(SEL)

⑩ F5(DRAW)

Result Screen



Using Zoom to Enlarge the Sub-screen

Description

Use the following procedure to enlarge the main screen graph and then move it to the sub-screen.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, select G+G for Dual Screen.
3. Make V-Window settings for the main screen.

Execution

4. Input the function and draw the graph in the main screen.
5. Use Zoom to enlarge the graph, and then move it to the sub-screen.

● ● ● ● ●

Example **Draw the graph $y = x(x + 1)(x - 1)$ in the main screen, and then use Box Zoom to enlarge it.**

Use the following V-Window settings.

(Main Screen)

Xmin = –2, Xmax = 2, Xscale = 0.5

Ymin = –2, Ymax = 2, Yscale = 1

Procedure

① MENU GRPH • TBL

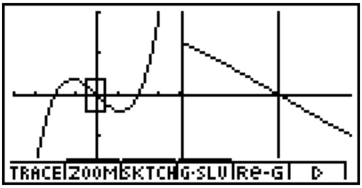
② CTRL F3 (SET UP) ▼ ▼ ▼ F2 (G+G) ESC

③ SHIFT OPTN (V-Window) (–) 2 EXE 2 EXE 0 • 5 EXE ▼
(–) 2 EXE 2 EXE 1 EXE ESC

④ F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 1) (X,θ,T – 1) EXE
F5 (DRAW)

⑤ F2 (ZOOM) 1 (BOX)
▼ ~ ▼ ▶ ~ ▶ EXE
▲ ~ ▲ ◀ ~ ◀ EXE

Result Screen



5-6 Manual Graphing

Rectangular Coordinate Graph

Description

Inputting the Graph command in the RUN • MAT Mode enables drawing of rectangular coordinate graphs.

Set Up

1. From the Main Menu, enter the RUN • MAT Mode.
2. Make V-Window settings.

Execution

3. Input the commands for drawing the rectangular coordinate graph.
4. Input the function.

● ● ● ● ●

Example **Graph $y = 2x^2 + 3x - 4$**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 2

Ymin = –10, Ymax = 10, Yscale = 5

Procedure

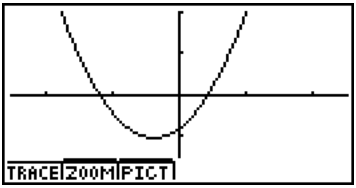
① MENU RUN • MAT

② SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 2 EXE ▼
(–) 1 0 EXE 1 0 EXE 5 EXE ESC

③ OPTN F6 (▷) F6 (▷) F2 (SKTCH) 1 (Cls) EXE
F2 (SKTCH) 4 (GRAPH) 1 (Y=)

④ 2 X,θ,T x^2 + 3 X,θ,T − 4 EXE

Result Screen



Integration Graph

Description

Inputting the Graph command in the RUN • MAT Mode enables graphing of functions produced by an integration calculation.
The calculation result is shown in the lower left of the display, and the calculation range is blackened in the graph.

Set Up

1. From the Main Menu, enter the RUN • MAT Mode.
2. Make V-Window settings.

Execution

3. Input graph commands for the integration graph.
4. Input the function.

● ● ● ● ●

Example **Graph the integration $\int_{-2}^{1}(x+2)(x-1)(x-3)\,dx$.**

Use the following V-Window settings.

Xmin = –4, Xmax = 4, Xscale = 1

Ymin = –8, Ymax = 12, Yscale = 5

Procedure

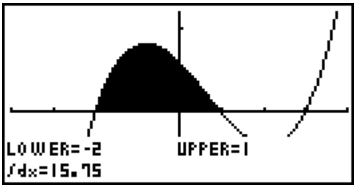
① MENU RUN • MAT

② SHIFT OPTN (V-Window) (–) 4 EXE 4 EXE 1 EXE ▼
(–) 8 EXE 1 2 EXE 5 EXE ESC

③ OPTN F6 (▷) F6 (▷) F2 (SKTCH) 1 (Cls) EXE
F2 (SKTCH) 4 (GRAPH) 2 (∫ dx)

④ (X,θ,T + 2) (X,θ,T − 1) (X,θ,T − 3) ,
(–) 2 , 1 EXE

Result Screen



LOWER=-2 UPPER=1
∫dx=15.75

Drawing Multiple Graphs on the Same Screen

Description

Use the following procedure to assign various values to a variable contained in an expression and overwrite the resulting graphs on the screen.

Set Up

1. From the Main Menu, Enter GRPH • TBL Mode.
2. Make V-Window settings.

Execution

3. Specify the function type and input the function. The following is the syntax for function input.

   Expression containing one variable , SHIFT + ([ ) variable SHIFT • (=) value , value , ... , value SHIFT − ( ])

4. Draw the graph.

• • • • •

Example **To graph $y = Ax^2 - 3$ as the value of A changes in the sequence 3, 1, –1.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

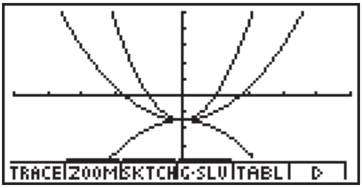
① MENU GRPH • TBL

② SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼
(–) 1 0 EXE 1 0 EXE 2 EXE ESC

③ F3 (TYPE) 1 (Y=) ALPHA X,θ,T (A) X,θ,T x^2 − 3 ,
SHIFT + ([ ) ALPHA X,θ,T (A) SHIFT • (=) 3 , 1 , (–) 1 SHIFT − ( ]) EXE

④ F5 (DRAW)

Result Screen



The value of only one of the variables in the expression can change.
Any of the following cannot be used for the variable name: X, Y, r, θ, T.
You cannot assign a variable to the variable inside the function.
When Simul Graph is turned on, all of the graphs for the specified variable values are drawn simultaneously.
Overwrite can be used when graphing rectangular expressions, polar expressions, parametric functions, X = constant functions, and inequalities.

5-7 Using Tables

Storing a Function and Generating a Number 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 Graph 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

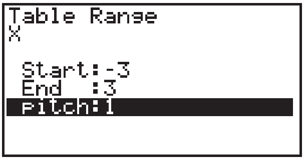
With this method, the data in the list you specify is substituted for the x-variable to generate a number table.

• To generate a table using a table range

• • • • •
Example **To generate a table as the value of variable x changes from –3 to 3, in increments of 1**

F6 (▷) F2 (RANG)

(–) 3 EXE 3 EXE 1 EXE



```
Table Range
X

 Start:-3
 End  :3
 pitch:1
```

The numeric table range defines the conditions under which the value of variable x changes during function calculation.

Start .... Variable x start value
End .... Variable x end value
pitch .... Variable x value change (interval)

After specifying the table range, press ESC to return to the Graph function list.

• To generate a table using a list

1. While the Graph function list is on the screen, display the SET UP screen.
2. Highlight Variable and then press F2(LIST) to display the pop-up window.
3. Select the list whose values you want to assign for the x-variable.
   - To select List 6, for example, press 6 EXE. This causes the setting of the Variable item of the SET UP screen to change to List 6.
4. After specifying the list you want to use, press ESC to return to the previous screen.

- Note that the {RANG} item does not appear when a list name is specified for the Variable item of the SET UP screen.

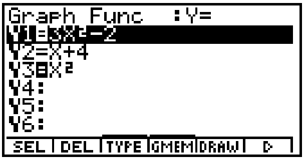
• Generating a Table

• • • • •

Example **To generate a table of values for the functions stored in memory areas Y1 and Y3 of the Graph function list**

Use ▲ and ▼ to move the highlighting to the function you want to select for table generation and press F1(SEL) to select it.

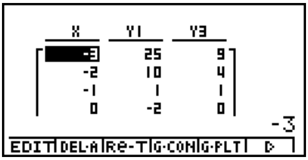
The "=" sign of selected functions is highlighted on the screen. To deselect a function, move the cursor to it and press F1(SEL) again.



Graph Func :Y=
Y1=3X²−2
Y2=X+4
Y3=X²
Y4:
Y5:
Y6:

Press F5(TABL) to generate a number table using the functions you selected. The value of variable x changes according to the range or the contents of the list you specified.

The example screen shown here shows the results based on the contents of List 6 (– 3, –2, –1, 0, 1, 2, 3).



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

Each cell can contain up to six digits, including negative sign.

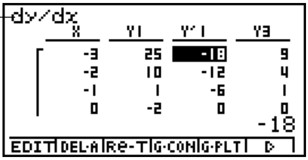
You can use cursor keys to move the highlighting around the table for the following purposes.

- To display the selected cell's value at the bottom of the screen, using the calculator's current number of decimal place, number of significant digit, and exponential display range settings
- To scroll the display and view parts of the table that do not fit in the display
- To display at the top of the screen the scientific function that produced the value in the selected cell (in columns Y1, Y2, etc.)
- To change x variable values by replacing values in column X

Press ESC to return to the Graph function list.

• To generate a differential number table *1

Changing the setting of SET UP screen's Derivative item to On causes a number table that includes the derivative to be displayed whenever you generate a number table.



Locating the cursor at a differential coefficient displays "dy/dx" in the top line, which indicates differential.

dy/dx

X	Y1	Y'1	Y3
-3	25	-18	9
-2	10	-12	4
-1	1	-6	1
0	-2	0	0

-18

• Specifying the function type

You can specify a function as being one of three types.*2

- Rectangular coordinate (Y=)
- Polar coordinate (r =)
- Parametric (Param)

1. Press F3 (TYPE) while the function list is on the screen.
2. Press the number key that corresponds to the function type you want to specify.

---

[1] An error occurs if a graph for which a range is specified or an overwrite graph is included among the graph expressions.

[2] The number table is generated only for the function type specified on the function list (Graph Func). You cannot generate a number table for a mixture of different function types.

■ Editing and Deleting Functions

• To edit a function

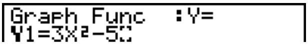
● ● ● ● ●
Example **To change the function in memory area Y1 from $y = 3x^2 - 2$ to $y = 3x^2 - 5$**

Use ▲ and ▼ to move the highlighting to the function you want to edit.

Graph Func :Y=
Y1=3X²-2

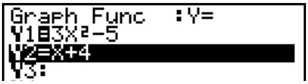
Use ◀ and ▶ to move the cursor to the location of the change.

▶ ▶ ▶ ▶ ▶ DEL 5



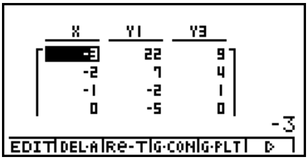
Graph Func :Y=
Y1=3X²-5

EXE



Graph Func :Y=
Y1■3X²-5
Y2=X+4
Y3:

F6 (▷) F5 (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 GRPH • TBL Mode list, and DYNA Mode list.

• To delete a function

1. Use ▲ and ▼ to move the highlighting to the function you want to delete and then press F2 (DEL) or DEL.
2. Press EXE (Yes) to delete the function or ESC (No) to abort the operation without deleting anything.

Editing Tables

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 and regenerate table
- Draw a connect type graph
- Draw a plot type graph

While the Table & Graph menu is on the display, press F5(TABL) to display the table menu.

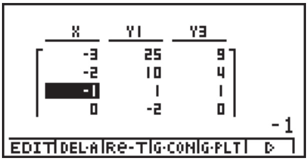
- {**EDIT**} ... {edit value of x-variable}
- {**DEL·A**} ... {delete table}
- {**Re-T**} ... {regenerate table from function}
- {**G·CON**}/{**G·PLT**} ... {connected type}/{draw plot type} graph draw
- {**R·DEL**}/{**R·INS**}/{**R·ADD**} ... {delete}/{insert}/{add} row

• To change variable values in a table

● ● ● ● ●

Example **To change the value in Column x, Row 3 of the table generated on page 5-7-2 from – 1 to – 2.5**

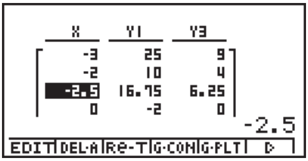
⏷ ⏷



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-1

(–) 2 • 5 EXE



X	Y1	Y3
-3	25	9
-2	10	4
-2.5	16.75	6.25
0	-2	0

-2.5

- When you change a variable value in Column x, all values in the columns to the right are recalculated and displayed.

If you try to replace a value with an illegal operation (such as division by zero), an error occurs and the original value remains unchanged.

You cannot directly change any values in the other (non-x) columns of the table.

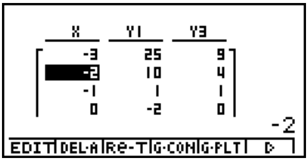
• Row Operations

• To delete a row

● ● ● ● ●

Example **To delete Row 2 of the table generated on page 5-7-2**

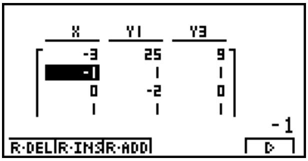
▼



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-2

F6(▷) F1(R·DEL)



X	Y1	Y3
-3	25	9
-1	1	1
0	-2	0
1	1	1

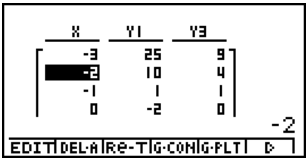
-1

• To insert a row

● ● ● ● ●

Example **To insert a new row between Rows 1 and 2 in the table generated on page 5-7-2**

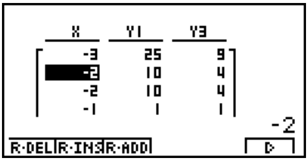
▼



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-2

F6(▷) F2(R·INS)



X	Y1	Y3
-3	25	9
-2	10	4
-2	10	4
-1	1	1

-2

• To add a row

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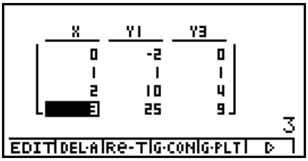
Example **To add a new row below Row 7 in the table generated on page 5-7-2**

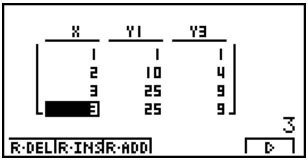
▼ ▼ ▼ ▼ ▼ ▼



X	Y1	Y3
0	-2	0
1	1	1
2	10	4
3	25	9

3

F6(▷)F3(R·ADD)



X	Y1	Y3
1	1	1
2	10	4
3	25	9
3	25	9

3

• Deleting a Table

1. Display the table and then press F2(DEL·A).
2. Press EXE(Yes) to delete the table or ESC(No) to abort the operation without deleting anything.

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(LMEM)

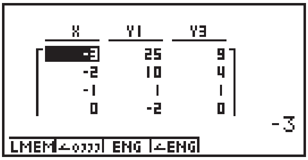
Store In
List Memory
List[1~20]:

-3

- You can select any row of the column you want to copy.

Input the number of the list you want to copy and then press EXE.

1 EXE



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

Drawing a Graph from a Number Table

Description

Use the following procedure to generate a number table and then draw a graph based on the values in the table.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make V-Window settings.

Execution

3. Store the functions.
4. Specify the table range.
5. Generate the table.
6. Select the graph type and draw it.
   F4 (G • CON) ... line graph[*1]
   F5 (G • PLT) ... plot type graph[*1][*2]

[*1] After drawing the graph, pressing CTRL F5 (G ↔ T) or ESC returns to the function storage screen. To return to the number table screen, press F5 (TABL).

[*2] Pressing F6 (▷) F4 (G • PLT) on the function storage screen generates the number table and plots the graph simultaneously.

• • • • •

Example **Store the two functions below, generate a number table, and then draw a line graph. Specify a range of –3 to 3, and an increment of 1.**
Y1 = $3x^2 - 2$, Y2 = x^2

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1
Ymin = –2, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL
② SHIFT OPTN (V-Window) 0 EXE 6 EXE 1 EXE ▼
(–) 2 EXE 1 0 EXE 2 EXE ESC
③ F3 (TYPE) 1 (Y=) 3 X,θ,T x^2 − 2 EXE
X,θ,T x^2 EXE
④ F6 (▷) F2 (RANG) (–) 3 EXE 3 EXE 1 EXE ESC
⑤ F5 (TABL)
⑥ F4 (G • CON)

Result Screen

You can use Trace, Zoom, or Sketch after drawing a graph.

Specifying a Range for Number Table Generation

Description

Use the following procedure to specify a number table range when calculating scatter data from a function.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.

Execution

2. Store the functions.
3. Specify the table range.
4. Select the functions for which you want to generate a table.
   The "=" sign of selected functions is highlighted on the screen.
5. Generate the table.

● ● ● ● ●

Example **Store the three functions shown below, and then generate a table for functions Y1 and Y3. Specify a range of –3 to 3, and an increment of 1.**

Y1 = $3x^2 - 2$, Y2 = $x + 4$, Y3 = x^2

Procedure

① MENU GRPH • TBL

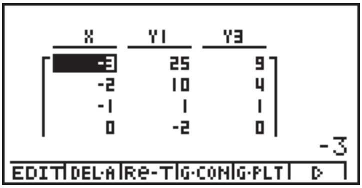
② F3 (TYPE) 1 (Y=) 3 X,θ,T x^2 − 2 EXE
X,θ,T + 4 EXE
X,θ,T x^2 EXE

③ F6 (▷) F2 (RANG) (−) 3 EXE 3 EXE 1 EXE ESC

④ ▲ ▲ F1 (SEL)

⑤ F5 (TABL)

Result Screen



X	Y1	Y3
-3	25	9
-2	10	4
-1	1	1
0	-2	0

-3

You can generate number tables from rectangular coordinate, polar coordinate, and parametric functions.

You can include derivatives in generated number tables by specifying On for the Derivative item on the SET UP screen.

Simultaneously Displaying a Number Table and Graph

Description

Specifying T+G for Dual Screen on the SET UP makes it possible to display a number table and graph at the same time.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make V-Window settings.
3. On the SET UP screen, select T+G for Dual Screen.

Execution

4. Input the function.
5. Specify the table range.
6. The number table is displayed in the sub-screen on the right.
7. Specify the graph type and draw the graph.
   F4 (G • CON) ... line graph
   F5 (G • PLT) ... plot type graph[1]

---

[1] Pressing F6 (▷) F4 (G • PLT) on the function storage screen generates the number table and plots the graph simultaneously.

• • • • •

Example **Store the function Y1 = $3x^2 - 2$ and simultaneously display its number table and line graph. Use a table range of –3 to 3 with an increment of 1.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = –2, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL

② SHIFT OPTN (V-Window) 0 EXE 6 EXE 1 EXE ▼
(–) 2 EXE 1 0 EXE 2 EXE ESC

③ CTRL F3 (SET UP) ▼ ▼ ▼ F1 (T+G) ESC

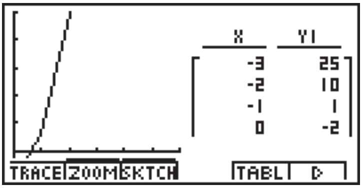
④ F3 (TYPE) 1 (Y=) 3 X,θ,T x^2 − 2 EXE

⑤ F6 (▷) F2 (RANG)
(–) 3 EXE 3 EXE 1 EXE ESC

⑥ F5 (TABL)

⑦ F4 (G • CON)

Result Screen



X	Y1
-3	25
-2	10
-1	1
0	-2

■ Using Graph-Table Linking

Description

With Dual Graph, you can use the following procedure to link the graph and table screens so the pointer on the graph screen jumps to the location of the currently selected table value.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. Make the required V-Window settings.

   Display the SET UP screen, select the Dual Screen item, and change its setting to "T+G".

Execution

3. Input the function of the graph and make the required table range settings.
4. With the number table on the right side of the display, draw the graph on the left side.

   F4(G • CON) ... connect type graph

   F5(G • PLT) ... plot type graph
5. Turn on G • Link.
6. Now when you use ▼ and ▲ to move the highlighting among the cells in the table, the pointer jumps to the corresponding point on the graph screen.
   If there are multiple graphs, pressing ◀ and ▶ causes the pointer to jump between them.

To turn off G • Link, press ESC or SHIFT ESC(QUIT).

● ● ● ● ●
Example **Store the function Y1 = 3log$x$ and simultaneously display its number table and plot-type graph. Use a table range of 2 through 9, with an increment of 1.**

Use the following V-Window settings.

Xmin = –1, Xmax = 10, Xscale = 1

Ymin = –1, Ymax = 4, Yscale = 1

Procedure

① MENU GRPH • TBL

② SHIFT OPTN (V-Window) (–) 1 EXE 1 0 EXE 1 EXE ▼
(–) 1 EXE 4 EXE 1 EXE ESC
CTRL F3 (SET UP) ▼ ▼ ▼ F1 (T+G) ESC

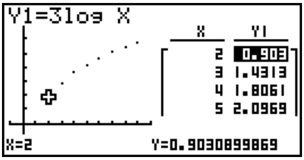
③ F3 (TYPE) 1 (Y=) 3 log X,θ,T EXE
F6 (▷) F2 (RANG)
2 EXE 9 EXE 1 EXE ESC

④ F5 (TABL)
F5 (G • PLT)

⑤ F6 (▷) F4 (G • Link)

⑥ ▼ ~ ▼, ▲ ~ ▲

Result Screen

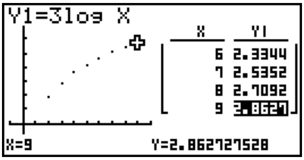


Y1=3log X

X	Y1
2	0.903
3	1.4313
4	1.8061
5	2.0969

X=2 Y=0.9030899869

···→
←···



Y1=3log X

X	Y1
6	2.3344
7	2.5352
8	2.7092
9	2.8627

X=9 Y=2.862727528

5-8 Dynamic Graphing

Using Dynamic Graph

Description

Dynamic Graph lets you define a range of values for the coefficients in a function, and then observe how a graph is affected by changes in the value of a coefficient. It helps to see how the coefficients and terms that make up a function influence the shape and position of a graph.

Set Up

1. From the Main Menu, enter the DYNA Mode.
2. Make V-Window settings.

Execution

3. On the SET UP screen, specify the Dynamic Type.
   F1(Cont) ... Continuous
   F2(Stop) ... Automatic stop after 10 draws
4. Use the cursor keys to select the function type on the built-in function type list.[*1]
5. Input values for coefficients, and specify which coefficient will be the dynamic variable.[*2]
6. Specify the start value, end value, and increment.
7. Specify the drawing speed.
   F3(SPEED) F1(▮▮▷) ..... Pause after each draw (Stop & Go)
   F2(▷) .... Half normal speed (Slow)
   F3(▶) .... Normal speed (Normal)
   F4(▷▷) ...... Twice normal speed (Fast)
8. Draw the Dynamic Graph.

[*1] The following are the seven built-in function types.
- $Y=AX+B$
- $Y=A(X–B)^2+C$
- $Y=AX^2+BX+C$
- $Y=AX^\wedge3+BX^2+CX+D$
- $Y=A\sin(BX+C)$
- $Y=A\cos(BX+C)$
- $Y=A\tan(BX+C)$

After you press F3(TYPE) and select the function type you want, you can then input the actual function.

1 ... rectangular coordinate expression
2 ... polar coordinate expression
3 ... parametric function

[*2] You could also press EXE here and display the parameter setting menu.

The message “Too Many Functions” appears when more than one function is selected for Dynamic Graphing.

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Example **Use Dynamic Graph to graph y = A (x – 1)^2 – 1, in which the value of coefficient A changes from 2 through 5 in increments of 1. The Graph is drawn 10 times.**

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DYNA

② SHIFT OPTN (V-Window) F1 (INIT) ESC

③ CTRL F3 (SET UP) F2 (Stop) ESC

④ F6 (▷) F3 (B-IN) ▼ F1 (SEL)

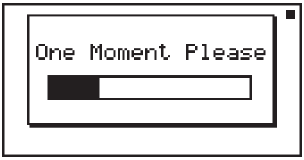
⑤ F6 (▷) F4 (VAR) 2 EXE 1 EXE (–) 1 EXE

⑥ F2 (RANG) 2 EXE 5 EXE 1 EXE ESC

⑦ F3 (SPEED) F3 (▸) ESC

⑧ F6 (DYNA)

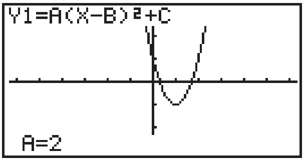
Result Screen



One Moment Please

Repeats from ① through ④.

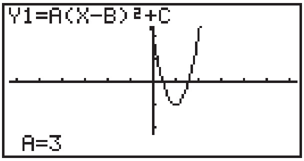
↓

① 

Y1=A(X-B)²+C

A=2

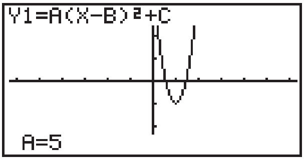
→
←

② 

Y1=A(X-B)²+C

A=3

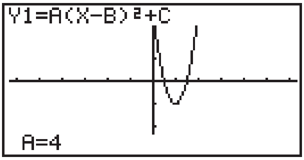
↓↑

④ 

Y1=A(X-B)²+C

A=5

→
←

③ 

Y1=A(X-B)²+C

A=4

Dynamic Graph Application Examples

Description

You can also use Dynamic Graph to simulate simple physical phenomena.

Set Up

1. From the Main Menu, enter the DYNA Mode.
2. Make V-Window settings.

Execution

3. On the SET UP screen, specify Stop for Dynamic Type and Deg for Angle.
4. Specify Param (parametric function) as the function type, and input a function that contains a dynamic variable.
5. Specify the dynamic coefficient.
6. Specify the start value, end value, and increment.
7. Specify Normal for the draw speed.
8. Start the Dynamic Graph operation.

• • • • •

Example **The path over time T of a ball thrown in the air at initial velocity V and an angle of θ degrees from horizontal can be calculated as follows.**

$X = (V\cos\theta)T$, $Y = (V\sin\theta)T - (1/2)gT^2$ ($g = 9.8\text{m/s}^2$)

Use Dynamic Graph to plot the path of a ball thrown at an initial velocity of 20 meters per second, at horizontal angles of 30, 45, and 60 degrees (Angle: Deg).

Use the following V-Window settings.

Xmin = –1,	**Xmax = 42,**	**Xscale = 5**
Ymin = –1,	**Ymax = 16,**	**Yscale = 2**
Tθmin = 0,	**Tθmax = 6,**	**Tθptch = 0.1**

Procedure

① MENU DYNA

② SHIFT OPTN (V-Window) (–) 1 EXE 4 2 EXE 5 EXE ▼
(–) 1 EXE 1 6 EXE 2 EXE
0 EXE 6 EXE 0 • 1 EXE ESC

③ CTRL F3 (SET UP) F2 (Stop)
▼ ▼ ▼ ▼ F1 (Deg) ESC

④ F3 (TYPE) 3 (Param)
(2 0 cos ALPHA X,θ,T (A)) X,θ,T EXE
(2 0 sin ALPHA X,θ,T (A)) X,θ,T — 4 • 9 X,θ,T x^2 EXE

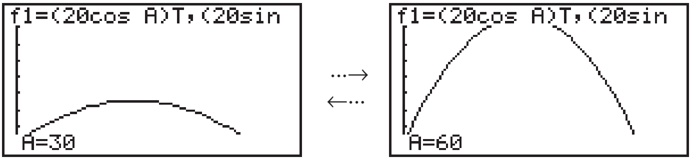
⑤ F4 (VAR)

⑥ F2 (RANG) 3 0 EXE 6 0 EXE 1 5 EXE ESC

⑦ F3 (SPEED) F3 (▸) ESC

⑧ F6 (DYNA)

Result Screen



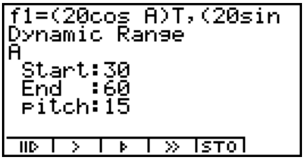
f1=(20cos A)T,(20sin
A=30

f1=(20cos A)T,(20sin
A=60

■ Adjusting 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.



```
f1=(20cos A)T,(20sin
Dynamic Range
A
 Start:30
 End  :60
 pitch:15
```

- {IID} ... {Each step of the Dynamic Graph draw operation is performed each time you press EXE.}
- {>}/{▸}/{>>} ... {slow (1/2 speed)}/{normal (default speed)}/{fast (double speed)}
- {**STO**} ... {stores graph conditions and screen data in Dynamic Graph memory}

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 CTRL F5 (G↔T) to return to the graph screen.

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
- V-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.
2. Press F6 (STO). In response to the confirmation dialog that appears, press EXE (Yes) to save the data.

• To recall data from Dynamic Graph memory

1. Display the Dynamic Graph function list.
2. Press F6 (RCL) to recall all the data stored in Dynamic Graph memory.

If there is already data stored in Dynamic Graph memory, the data save operation replaces it with the new data.

Data recalled from Dynamic Graph memory replaces the calculator's current graph functions, draw conditions, and screen data. The previous data is lost when it is replaced.

5-9 Graphing a Recursion Formula

Generating a Number Table from a Recursion Formula

Description

You can input up to three of the following types of recursion formulas and generate a number table.

- General term of sequence $\{a_n\}$, composed of a_n, n
- Linear two-term recursion composed of a_{n+1}, a_n, n
- Linear three-term recursion composed of a_{n+2}, a_{n+1}, a_n, n

---

Set Up

1. From the Main Menu, enter the RECUR Mode.

Execution

2. Specify the recursion type.

   F3(TYPE) 1(a_n=) ... {general term of sequence a_n}

   2(a_{n+1}=) ... {linear two-term recursion}

   3(a_{n+2}=) ... {linear three-term recursion}

3. Input the recursion formula.
4. Specify the table range. Specify a start point and end point for n. If necessary, specify a value for the initial term, and a pointer start point value if you plan to graph the formula.
5. Display the recursion formula number table.

• • • • •

Example **Generate a number table from recursion between three terms as expressed by $a_{n+2} = a_{n+1} + a_n$, with initial terms of $a_1 = 1$, $a_2 = 1$ (Fibonacci sequence), as n changes in value from 1 to 6.**

Procedure

① MENU RECUR

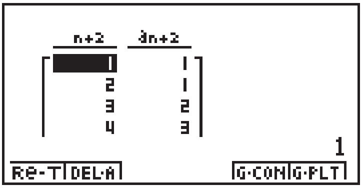
② F3 (TYPE) 3 (a_{n+2}=)

③ F4 (n. a_n ··) 3 (a_{n+1}) + F2 (a_n) EXE

④ F5 (RANG) F2 (a_1) 1 EXE 6 EXE 1 EXE 1 EXE ESC

⑤ F6 (TABL)

Result Screen



n+2	an+2
1	1
2	1
3	2
4	3

1

* The first two values correspond to $a_1 = 1$ and $a_2 = 1$.

Specifying On for the Σ Display of the SET UP screen causes the sum of each term to be included in the table.

Graphing a Recursion Formula (1)

Description

After generating a number table from a recursion formula, you can graph the values on a line graph or plot type graph.

Set Up

1. From the Main Menu, enter the RECUR Mode.
2. Make V-Window settings.

Execution

3. Specify the recursion formula type and input the formula.
4. Specify the table range, and start and ending values for n. If necessary, specify the initial term value and pointer start point.
5. Display the recursion formula number table.
6. Specify the graph type and draw the graph.
   F5(G•CON) ... line graph
   F6(G•PLT) ... plot type graph

● ● ● ● ●

Example **Generate a number table from recursion between two terms as expressed by $a_{n+1} = 2a_n+1$, with an initial term of $a_1 = 1$, as n changes in value from 1 to 6. Use the following table values to draw a line graph.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = –15, Ymax = 65, Yscale = 5

Procedure

① MENU RECUR

② SHIFT OPTN (V-Window) 0 EXE 6 EXE 1 EXE ▼

(–) 1 5 EXE 6 5 EXE 5 EXE ESC

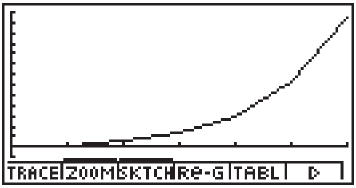
③ F3 (TYPE) 2 (a_{n+1}=) 2 F2 (a_n) + 1 EXE

④ F5 (RANG) F2 (a_1) 1 EXE 6 EXE 1 EXE ESC

⑤ F6 (TABL)

⑥ F5 (G • CON)

Result Screen



Graphing a Recursion Formula (2)

Description

The following describes how to generate a number table from a recursion formula and graph the values while Σ Display is On.

Set Up

1. From the Main Menu, enter the RECUR Mode.
2. On the SET UP screen, specify On for Σ Display.
3. Make V-Window settings.

Execution

4. Specify the recursion formula type and input the recursion formula.
5. Specify the table range, and start and ending values for n. If necessary, specify the initial term value and pointer start point.
6. Display the recursion formula number table.
7. Specify the graph type and draw the graph.

F5 (G • CON) 1 (a_n) ... Line graph with ordinate a_n, abscissa n
2 (Σa_n) ... Line graph with ordinate Σa_n, abscissa n
F6 (G • PLT) 1 (a_n) ... Plot type graph with ordinate a_n, abscissa n
2 (Σa_n) ... Plot type graph with ordinate Σa_n, abscissa n

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Example **Generate a number table from recursion between two terms as expressed by $a_{n+1} = 2a_n+1$, with an initial term of $a_1 = 1$, as n changes in value from 1 to 6. Use the table values to draw a plot line graph with ordinate Σa_n, abscissa n.**

Use the following V-Window settings.

Xmin = 0, Xmax = 6, Xscale = 1

Ymin = –15, Ymax = 65, Yscale = 5

Procedure

① MENU RECUR

② CTRL F3(SET UP) F1(On) ESC

③ SHIFT OPTN(V-Window) 0 EXE 6 EXE 1 EXE ▼
(–) 1 5 EXE 6 5 EXE 5 EXE ESC

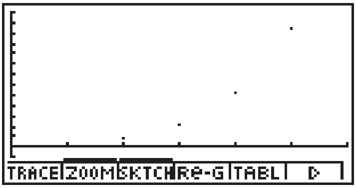
④ F3(TYPE) 2 (a_{n+1}=) 2 F2(a_n) + 1 EXE

⑤ F5(RANG) F2(a_1) 1 EXE 6 EXE 1 EXE ESC

⑥ F6(TABL)

⑦ F6(G • PLT) 2 (Σa_n)

Result Screen



WEB Graph (Convergence, Divergence)

Description

$y = f(x)$ is graphed by presuming $a_{n+1} = y$, $a_n = x$ for linear two-term regression $a_{n+1} = f(a_n)$ composed of a_{n+1}, a_n. Next, it can be determined whether the function is convergent or divergent.

Set Up

1. From the Main Menu, enter the RECUR Mode.
2. Make V-Window settings.

Execution

3. Select 2-term recursion as the recursion formula type, and input the formula.
4. Specify the table range, n start and end points, initial term value, and pointer start point.
5. Display the recursion formula number table.
6. Draw the graph.
7. Press EXE, and the pointer appears at the start point you specified.
   Press EXE several times.

   If convergence exists, lines that resemble a spider web are drawn on the display. Failure of the web lines to appear indicates either divergence or that the graph is outside the boundaries of the display screen. When this happens, change to larger View Window values and try again.

   You can use ▲ ▼ to select the graph.

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Example **To draw the WEB graph for the recursion formula $a_{n+1} = -3(a_n)^2 + 3a_n$, $b_{n+1} = 3b_n + 0.2$, and check for divergence or convergence. Use the following table range and V-Window Settings.**

Table Range

Start = 0, End = 6, a_0 = 0.01, a_nStr = 0.01, b_0 = 0.11, b_nStr = 0.11

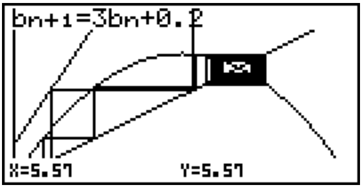
V-Window Settings

Xmin = 0, Xmax = 1, Xscale = 1
Ymin = 0, Ymax = 1, Yscale = 1

Procedure

① MENU RECUR
② SHIFT OPTN (V-Window) 0 EXE 1 EXE 1 EXE ▼
0 EXE 1 EXE 1 EXE ESC
③ F3 (TYPE) 2 (a_{n+1}=) (–) 3 F2 (a_n) x^2 + 3 F2 (a_n) EXE
3 F3 (b_n) + 0 . 2 EXE
④ F5 (RANG) F1 (a_0)
0 EXE 6 EXE 0 . 0 1 EXE 0 . 1 1 EXE ▼
0 . 0 1 EXE 0 . 1 1 EXE ESC
⑤ F6 (TABL)
⑥ F4 (WEB)
⑦ F1 (TRACE) EXE ~ EXE (a_n is convergence)
▼ EXE ~ EXE (b_n is divergence)

Result Screen



bn+1=3bn+0.2

X=5.57 Y=5.57

5-10 Changing the Appearance of a Graph

■ Drawing a Line

Description

The sketch function lets you draw points and lines inside of graphs.

Set Up

1. Draw the graph.

Execution

2. Select the sketch function you want to use.*[1]

F3 (SKTCH) 1 (Cls) ... Screen clear
2 (PLOT)
{On}/{Off}/{Change}/{Plot} ... Point {On}/{Off}/{Change}/{Plot}
3 (LINE)
{F-Line}/{Line} ... {Freehand line}/{Line}
4 (Text) ... Text input
5 (Pen) ... Freehand
6 (Tangnt) ... Tangent line
7 (Normal) ... Line normal to a curve
8 (Invrse) ... Inverse function*[2]
9 (Circle) ... Circle
X,θ,T (Vert) ... Vertical line
log (Horz) ... Horizontal line

3. Use the cursor keys to move the pointer (✛) to the location where you want to draw, and press EXE.*[3]

---

*[1] The above shows the function menu that appears in the GRPH • TBL Mode. Menu items may differ somewhat in other modes.

*[2] In the case of an inverse function graph, drawing starts immediately after you select this option.

*[3] Some sketch functions require specification of two points. After you press EXE to specify the first point, use the cursor keys to move the pointer to the location of the second point and press EXE.

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Example **Draw a line that is tangent to point (2, 0) on the graph for $y = x(x + 2)(x - 2)$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 5 EXE 5 EXE 1 EXE ESC

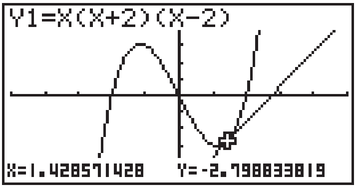
F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T – 2) EXE

F5 (DRAW)

② F3 (SKTCH) 6 (Tangnt)

③ ▶ ~ ▶ EXE [*1]

Result Screen



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

X=1.428571428 Y=-2.798833819

[*1] You can draw a tangent line in succession by moving the "✚" pointer and pressing EXE.

Inserting Comments

Description

You can insert comments anywhere you want in a graph.

Set Up

1. Draw the graph.

Execution

2. Press F3 (SKTCH) 4 (Text), and a pointer appears in the center of the display.
3. Use the cursor keys to move the pointer to the location where you want the text to be, and input the text.

\# You can input any of the following characters as comment text: A~Z, r, θ, space, 0~9, ., +, –, ×, ÷, (–), EXP, π, Ans, (,), [,], {, }, comma, →, x^2, ^, log, ln, $\sqrt{\ }$, $\sqrt[x]{\ }$, 10^x, e^x, $\sqrt[3]{\ }$, x^{-1}, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, i, List, Mat

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Example **Insert text into the graph $y = x(x + 2)(x - 2)$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 5 EXE 5 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

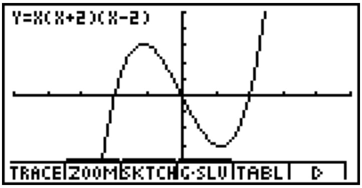
② F3 (SKTCH) 4 (Text)

③ ▲ ~ ▲ ◀ ~ ◀

ALPHA − (Y) SHIFT • (=) X,θ,T (X,θ,T + 2) (X,θ,T − 2)

ESC

Result Screen



Y=X(X+2)(X-2)

Freehand Drawing

Description

You can use the pen option for freehand drawing in a graph.

Set Up

1. Draw the graph.

Execution

2. Press F3(SKTCH) 5(Pen), and a pointer appears in the center of the screen.
3. Use the cursor keys to move the pointer to the point from which you want to start drawing, and then press EXE.
4. Use the cursor keys to move the pointer. A line is drawn wherever you move the pointer. To stop the line, press EXE.

   Repeat step 3 and 4 to draw other lines.

   After you are finished drawing, press ESC.

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Example **Use the pen to draw on the graph $y = x(x + 2)(x - 2)$.**

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (−) 5 EXE 5 EXE 1 EXE ▼

(−) 5 EXE 5 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

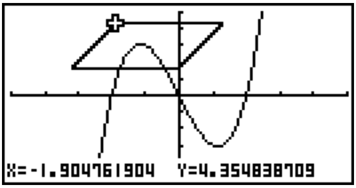
F5 (DRAW)

② F3 (SKTCH) 5 (Pen)

③ ▲~▲ ◀~◀ EXE

④ ▼◀···, ▶~▶, ▶▲···, ◀~◀ EXE

Result Screen



X=-1.904761904 Y=4.354838709

Changing the Graph Background

You can use the set up screen to specify the memory contents of any picture memory area (Pict 1 through Pict 20) as the Background item. When you do, the contents of the corresponding memory area is used as the background of the graph screen.

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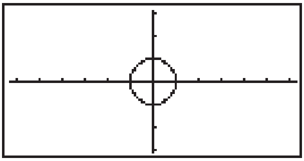
Example 1 With the circle graph $X^2 + Y^2 = 1$ as the background, use Dynamic Graph to graph $Y = X^2 + A$ as variable A changes value from –1 to 1 in increments of 1.

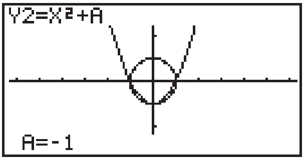
Recall the background graph.

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



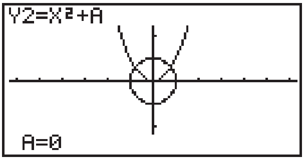
Draw the dynamic graph.

($Y = X^2 - 1$)



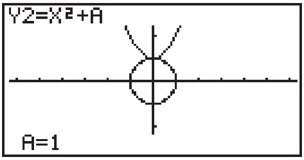
↓↑

($Y = X^2$)



↓↑

($Y = X^2 + 1$)



- See “5-8-1 Dynamic Graphing” for details on using the Dynamic Graph feature.

5-11 Function Analysis

Reading Coordinates on a Graph Line

Description

Trace lets you move a pointer along a graph and read out coordinates on the display.

Set Up

1. Draw the graph.

Execution

2. Press F1 (TRACE), and a pointer appears in the center of the graph.*1
3. Use ◀ and ▶ to move the pointer along the graph to the point at which you want to display the derivative.

   When there are multiple graphs on the display, press ▲ and ▼ to move between them along the x-axis of the current pointer location.
4. You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting coordinates.

   The pop-up window appears even when you input coordinates directly.

To exit a trace operation, press ESC.

---

*1 The pointer is not visible on the graph when it is located at a point outside the graph display area or when an error of no value occurs.

You can turn off display of the coordinates at the pointer location by specifying “Off” for the “Coord” item on the SET UP screen.

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Example **Read coordinates along the graph of the function shown below.**

Y1 = x^2 – 3

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 1 0 EXE 1 0 EXE 2 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T x^2 – 3 EXE

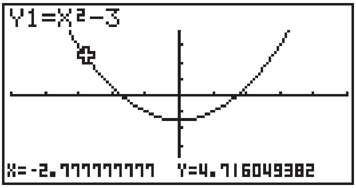
F5 (DRAW)

② F1 (TRACE)

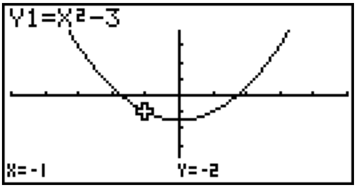
③ ◀ ~ ◀

④ (–) 1 EXE

Result Screen



```
Y1=X²−3
X=-2.777777777   Y=4.716049382
```



```
Y1=X²−3
X=-1             Y=-2
```

The following shows how coordinates are displayed for each function type.

- **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
```

Displaying the Derivative

Description

In addition to using Trace to display coordinates, you can also display the derivative at the current pointer location.

Set Up

1. On the SET UP screen, specify On for Derivative.
2. Draw the graph.

Execution

3. Press F1(TRACE), and the pointer appears at the center of the graph. The current coordinates and the derivative also appear on the display at this time.
4. Use ◀ and ▶ to move the pointer along the graph to the point at which you want to display the derivative.

   When there are multiple graphs on the display, press ▲ and ▼ to move between them along the x-axis of the current pointer location.
5. You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting coordinates.

   The pop-up window appears even when you input coordinates directly.

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Example **Read coordinates and derivatives along the graph of the function shown below.**

Y1 = x^2 – 3

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL

CTRL F3 (SET UP) ▼ ▼ ▼ ▼ ▼ F1 (On) ESC

② SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 1 0 EXE 1 0 EXE 2 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T x^2 – 3 EXE

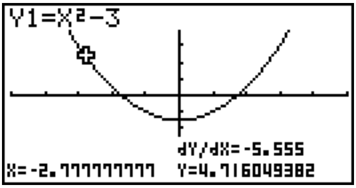
F5 (DRAW)

③ F1 (TRACE)

④ ◀ ~ ◀

⑤ (–) 1 EXE

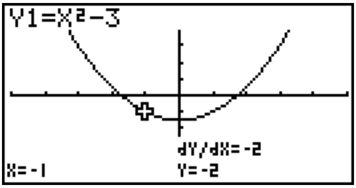
Result Screen



Y1=X^2–3

dY/dX=-5.555

X=-2.777777777 Y=4.716049382



Y1=X^2–3

dY/dX=-2

X=-1 Y=-2

■ Graph to Table

Description

You can use trace to read the coordinates of a graph and store them in a number table. You can also use Dual Graph to simultaneously store the graph and number table, making this an important graph analysis tool.

Set Up

1. From the Main Menu, enter the GRPH • TBL Mode.
2. On the SET UP screen, specify GtoT for Dual Screen.
3. Make V-Window settings.

Execution

4. Save the function and draw the graph on the active (left) screen.
5. Activate Trace. When there are multiple graphs on the display, press ▲ and ▼ to select the graph you want.
6. Use ◀ to move the pointer and press EXE to store coordinates into the number table. Repeat this step to store as many values as you want.
7. Press F6 (CHNG) to switch the number table side.
8. From the pop-up window, input the list number you want to save.

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Example **Save, in a table, the coordinates in the vicinity of the points of intersection at X = 0 for the two graphs shown below, and store the table contents in List 1.**

Y1 = x^2 – 3, Y2 = – x + 2

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL

② CTRL F3 (SET UP) ▼ ▼ ▼ F3 (GtoT) ESC

③ SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼
(–) 1 0 EXE 1 0 EXE 2 EXE ESC

④ F3 (TYPE) 1 (Y=) X,θ,T x^2 – 3 EXE
(–) X,θ,T + 2 EXE
F5 (DRAW)

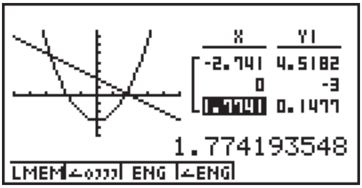
⑤ F1 (TRACE)

⑥ ◀ ~ ◀ EXE ▶ ~ ▶ EXE ESC

⑦ F6 (CHNG)

⑧ OPTN F1 (LMEM) 1 EXE

Result Screen



X	Y1
-2.741	4.5182
0	-3
1.7741	0.1477

1.774193548

Coordinate Rounding

Description

This function rounds off coordinate values displayed by Trace.

Set Up

1. Draw the graph.

Execution

2. Press F2(ZOOM) 8 (Rnd). This causes the V-Window settings to be changed automatically in accordance with the Rnd value.
3. Press F1(TRACE), and then use the cursor keys to move the pointer along the graph. The coordinates that now appear are rounded.

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Example **Use coordinate rounding and display the coordinates in the vicinity of the points of intersection for the two graphs produced by the functions shown below.**

Y1 = x^2 – 3, Y2 = – x + 2

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –10, Ymax = 10, Yscale = 2

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 1 0 EXE 1 0 EXE 2 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T x^2 – 3 EXE

(–) X,θ,T + 2 EXE

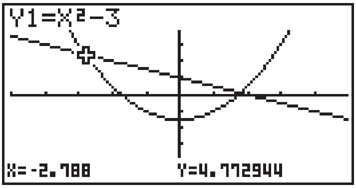
F5 (DRAW)

② F2 (ZOOM) 8 (Rnd)

③ F1 (TRACE)

◀ ~ ◀

Result Screen



Y1=X²–3

X=-2.788 Y=4.772944

■ Calculating the Root

Description

This feature provides a number of different methods for analyzing graphs.

Set Up

1. Draw the graphs.

Execution

2. Select the analysis function.

   F4(G-SLV) 1(Root) ... Calculation of root
   2(Max) ... Local maximum value
   3(Min) ... Local minimum value
   4(Y-Icpt) ... y-intercept
   5(Isect) ... Intersection of two graphs
   6(Y-Cal) ... y-coordinate for given x-coordinate
   7(X-Cal) ... x-coordinate for given y-coordinate
   8($\int dx$) ... Integral value for a given range

3. When there are multiple graphs on the screen, the selection cursor (■) is located at the lowest numbered graph. Use the cursor keys to move the cursor to the graph you want to select.

4. Press EXE to select the graph where the cursor is located and display the value produced by the analysis.
   When an analysis produces multiple values, press ▶ to calculate the next value.
   Pressing ◀ returns to the previous value.

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Example **Draw the graph shown below and calculate the root for Y1.**
Y1 = $x(x + 2)(x - 2)$

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) F1 (INIT) ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

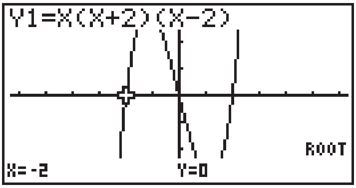
② F4 (G-SLV) 1 (Root)

⋮

④ ▶

▶

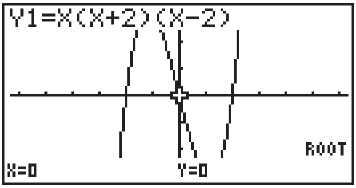
Result Screen



Y1=X(X+2)(X−2)

ROOT

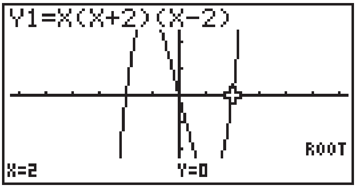
X= -2 Y=0



Y1=X(X+2)(X−2)

ROOT

X=0 Y=0



Y1=X(X+2)(X−2)

ROOT

X=2 Y=0

When analyzing a single graph, results appear as soon as you select an analysis function in step 2, so step 3 is not necessary.

Root, local maximum value, local minimum value, and y-intercept can be calculated for rectangular coordinate graphs and inequality graphs only.

The y-intercept is the point where the graph crosses the y-axis.

■ Calculating the Point of Intersection of Two Graphs

Description

Use the following procedure to calculate the point of intersection of two graphs.

Set Up

1. Draw the graphs.

Execution

2. Press F4(G-SLV)F5(Isect). When there are three or more graphs, the selection cursor (■) appears at the lowest numbered graph.
3. Use the cursor keys to move the cursor to the graph you want to select.
4. Press EXE to select the first graph, which changes the shape of the cursor from ■ to ◆.
5. Use the cursor keys to move the cursor to the second graph.
6. Press EXE to calculate the point of intersection for the two graphs.
   When an analysis produces multiple values, press ▶ to calculate the next value.
   Pressing ◀ returns to the previous value.

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Example **Graph the two functions shown below, and determine the point of intersection between Y1 and Y2.**

Y1 = x + 1, Y2 = x^2

Use the following V-Window settings.

Xmin = –5, Xmax = 5, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 5 EXE 5 EXE 1 EXE ▼

(–) 5 EXE 5 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T + 1 EXE

X,θ,T x^2 EXE

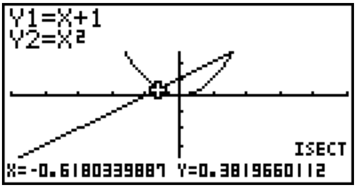
F5 (DRAW)

② F4 (G-SLV) 5 (Isect)

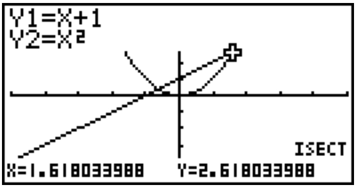
⋮

⑥ ▶

Result Screen



```
Y1=X+1
Y2=X²
                ISECT
X=-0.6180339887 Y=0.3819660112
```



```
Y1=X+1
Y2=X²
                ISECT
X=1.618033988   Y=2.618033988
```

In the case of two graphs, the point of intersection is calculated immediately after you press F4 5 in step 2.

You can calculate the point of intersection for rectangular coordinate graphs and inequality graphs only.

■ Determining the Coordinates for Given Points

Description

The following procedure describes how to determine the y-coordinate for a given x, and the x-coordinate for a given y.

Set Up

1. Draw the graph.

Execution

2. Select the function you want to perform. When there are multiple graphs, the selection cursor (■) appears at the lowest numbered graph.

   F4(G-SLV) 6(Y-Cal) ... y-coordinate for given x

   7(X-Cal) ... x-coordinate for given y

3. Use ▲ ▼ to move the cursor (■) to the graph you want, and then press EXE to select it.

4. Input the given x-coordinate value or y-coordinate value.
   Press EXE to calculate the corresponding y-coordinate value or x-coordinate value.

● ● ● ● ●

Example **Graph the two functions shown below and then determine the y-coordinate for x = 0.5 and the x-coordinate for y = 2.2 on graph Y2.**

Y1 = x + 1, Y2 = $x(x + 2)(x - 2)$

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) F1 (INIT) ESC

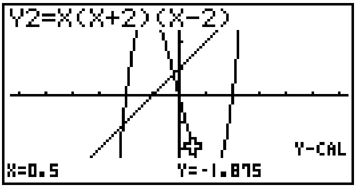
F3 (TYPE) 1 (Y=) X,θ,T + 1 EXE

X,θ,T (X,θ,T + 2) (X,θ,T − 2) EXE

F5 (DRAW)

② F4 (G-SLV) 6 (Y-Cal)	② F4 (G-SLV) 7 (X-Cal)
③ ▼ EXE	③ ▼ EXE
④ 0 • 5 EXE	④ 2 • 2 EXE

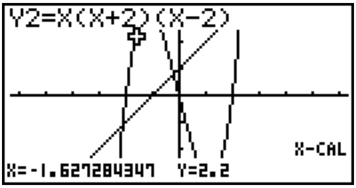
Result Screen



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

Y-CAL

X=0.5 Y=-1.875



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

X-CAL

X=-1.627284347 Y=2.2

When there are multiple results for the above procedure, press ► to calculate the next value. Pressing ◄ returns to the previous value.

Step 3 of the above procedure is skipped when there is only one graph on the display.

The X-Cal value cannot be obtained for a parametric function graph.

After obtaining coordinates with the above procedure, you can input different coordinates by first pressing X,θ,T.

Calculating the Integral Value for a Given Range

Description

Use the following procedure to obtain integration values for a given range.

Set Up

1. Draw the graph.

Execution

2. Press F4 (G-SLV) 8 ($\int dx$). When there are multiple graphs, this causes the selection cursor (■) to appear at the lowest numbered graph.
3. Use ▲ ▼ to move the cursor (■) to the graph you want, and then press EXE to select it.
4. Use ◀ to move the lower limit pointer to the location you want, and then press EXE.

   You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting coordinates.
5. Use ▶ to move the upper limit pointer to the location you want.

   You can also move the pointer by pressing X,θ,T to display the pop-up window, and then inputting the upper limit and lower limit values for the integration range.
6. Press EXE to calculate the integral value.

You can also specify the lower limit and upper limit by inputting them on the 10-key pad.

When setting the range, make sure that the lower limit is less than the upper limit.

Integral values can be calculated for rectangular coordinate graphs only.

• • • • •

Example **Graph the function shown below, and then determine the integral value at (–2, 0).**

Y1 = $x(x + 2)(x - 2)$

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –4, Ymax = 4, Yscale = 1

Procedure

① MENU GRPH • TBL

SHIFT OPTN (V-Window) (–) 6 • 3 EXE 6 • 3 EXE 1 EXE ▼

(–) 4 EXE 4 EXE 1 EXE ESC

F3 (TYPE) 1 (Y=) X,θ,T (X,θ,T + 2) (X,θ,T – 2) EXE

F5 (DRAW)

② F4 (G-SLV) 8 (∫dx)

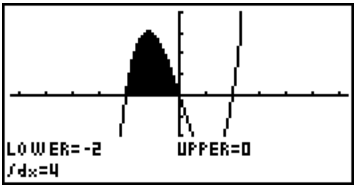
⋮

④ ◀ ~ ◀ EXE

⑤ ▶ ~ ▶ (Upper limit; x = 0)

⑥ EXE

Result Screen



LOWER=-2 UPPER=0

∫dx=4

Conic Section Graph Analysis

You can determine approximations of the following analytical results using conic section graphs.

- Focus/vertex/eccentricity
- Latus rectum
- Center/radius
- x-/y-intercept
- Directrix/axis of symmetry drawing and analysis
- Asymptote drawing and analysis

After graphing a conic section, press F4 (G-SLV) to display the following graph analysis menus.

• Parabolic Graph Analysis

- {**Focus**}/{**Vertex**}/{**Length**}/{**e**} ... {focus}/{vertex}/{latus rectum}/{eccentricity}
- {**Dirtrx**}/{**Sym**} ... {directrix}/{axis of symmetry}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

• Circular Graph Analysis

- {**Center**}/{**Radius**} ... {center}/{radius}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

• Elliptical Graph Analysis

- {**Focus**}/{**Vertex**}/{**Center**}/{**e**} ... {focus}/{vertex}/{center}/{eccentricity}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

• Hyperbolic Graph Analysis

- {**Focus**}/{**Vertex**}/{**Center**}/{**e**} ... {focus}/{vertex}/{center}/{eccentricity}
- {**Asympt**} ... {asymptote}
- {**X-Icpt**}/{**Y-Icpt**} ... {x-intercept}/{y-intercept}

The following examples show how to use the above menus with various types of conic section graphs.

• To calculate the focus, vertex and latus rectum

[G-SLV]-[Focus]/[Vertex]/[Length]

• • • • •

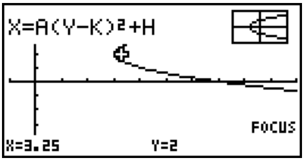
Example **To determine the focus, vertex and latus rectum for the parabola $X = (Y - 2)^2 + 3$**

Use the following V-Window settings.

Xmin = –1, Xmax = 10, Xscale = 1

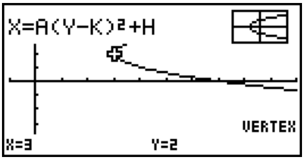
Ymin = –5, Ymax = 5, Yscale = 1

F4(G-SLV)
1(Focus)
(Calculates the focus.)



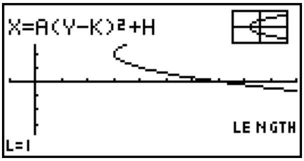
```
X=A(Y-K)²+H
FOCUS
X=3.25        Y=2
```

ESC
F4(G-SLV)
3(Vertex)
(Calculates the vertex.)



```
X=A(Y-K)²+H
VERTEX
X=3           Y=2
```

ESC
F4(G-SLV)
5(Length)
(Calculates the latus rectum.)



```
X=A(Y-K)²+H
LENGTH
L=1
```

- 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 an ellipse or hyperbolic graph, press ▶ to calculate the second vertex. Pressing ◀ returns to the first vertex.

• To calculate the center and radius **[G-SLV]-[Center]/[Radius]**

• • • • •

Example **To determine the center and radius for the circle $(X + 2)^2 + (Y + 1)^2 = 2^2$**

Use the following V-Window settings.

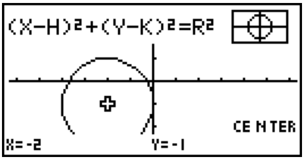
Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1

F4(G-SLV)

1(Center)

(Calculates the center.)



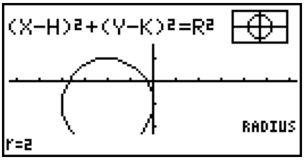
X=-2 Y=-1

ESC

F4(G-SLV)

2(Radius)

(Calculates the radius.)



r=2

• To calculate the x- and y-intercepts **[G-SLV]-[X-Icpt]/[Y-Icpt]**

• • • • •

Example **To determine the x- and y-intercepts for the hyperbola**

$$\frac{(X-3)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

Use the following V-Window settings.

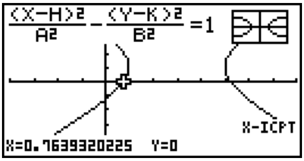
Xmin = –4, Xmax = 8, Xscale = 1

Ymin = –5, Ymax = 5, Yscale = 1

F4(G-SLV)

6(X-Icpt)

(Calculates the x-intercept.)



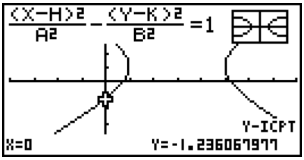
X=0.7639320225 Y=0

ESC

F4 (G-SLV)

7 (Y-Icpt)

(Calculates the y-intercept.)



$\frac{(X-H)^2}{A^2}-\frac{(Y-K)^2}{B^2}=1$

Y-ICPT

X=0 Y=-1.236067977

- Press ▶ to calculate the second set of x-/y-intercepts. Pressing ◀ returns to the first set of intercepts.

• To draw and analyze the axis of symmetry and directrix

[G-SLV]-[Sym]/[Dirtrx]

● ● ● ● ●

Example **To draw the axis of symmetry and directrix for the parabola $X = 2(Y - 1)^2 + 1$**

Use the following V-Window settings.

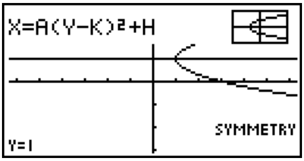
Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1

F4 (G-SLV)

4 (Sym)

(Draws the axis of symmetry.)



X=A(Y-K)²+H

SYMMETRY

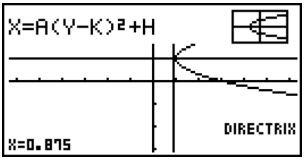
Y=1

ESC

F4 (G-SLV)

2 (Dirtrx)

(Draws the directrix.)



X=A(Y-K)²+H

DIRECTRIX

X=0.875

• To draw and analyze the asymptotes **[G-SLV]-[Asympt]**

• • • • •

Example **To draw the asymptotes for the hyperbola**

$$\frac{(X-1)^2}{2^2} - \frac{(Y-1)^2}{2^2} = 1$$

Use the following V-Window settings.

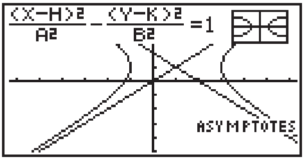
Xmin = −6.3, Xmax = 6.3, Xscale = 1

Ymin = −5, Ymax = 5, Yscale = 1

F4 (G-SLV)

4 (Asympt)

(Draws the asymptotes.)



• To calculate eccentricity **[G-SLV]-[*e*]**

• • • • •

Example **To determine the eccentricity of the graph for ellipse**

$$\frac{(X-2)^2}{4^2} + \frac{(Y-2)^2}{2^2} = 1$$

Use the following V-Window settings.

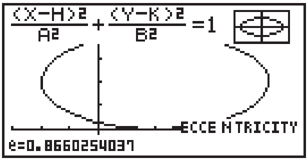
Xmin = −3, Xmax = 7, Xscale = 1

Ymin = −1, Ymax = 5, Yscale = 1

F4 (G-SLV)

4 (*e*)

(Calculates eccentricity.)



e=0.8660254037

Certain V-Window parameters can produce errors in values produced as graph analysis results.

The message "Not Found" appears on the display when graph analysis is unable to produce a result.

The following can result in inaccurate analysis results or may even make it impossible to obtain a solution at all.

— When the solution is tangent to the *x*-axis.

— When the solution is a point of tangency between two graphs.

Chapter 6

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 appear on the screen when you perform a graphing operation will probably differ somewhat from those shown in this manual.

6-1 Before Performing Statistical Calculations

From the Main Menu, 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.

	List 1	List 2	List 3	List 4
1				
2				
3				
4				
5				

GRPH CALC TEST INTR DIST ▷

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.

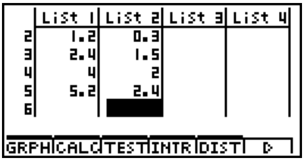
Inputting Data into Lists

● ● ● ● ●

Example **To input the following two data groups**

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

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				

GRPH CALC TEST INTR DIST ▷

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

Except for complex numbers, calculation results can be input as statistical data.

You can use the ▲, ▼, ◀ and ▶ keys to move the highlighting to any cell in the lists for data input.

Changing Graph Parameters

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

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

- {**S-Gph1**}/{**S-Gph2**}/{**S-Gph3**} ... graph {1}/{2}/{3} drawing[1]
- {**Select**} ... {simultaneous graph (GPH1, GPH2, GPH3) selection} (You can specify the multiple graphs.)
- {**Set**} ... {graph settings (graph type, list assignments)}

1. General graph settings **[GRPH]-[Set]**

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

• Graph Type

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

• List

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

• Frequency

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

[1] 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.

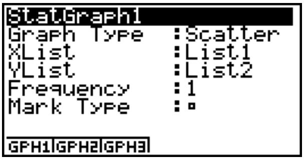
You can specify the graph draw/non-draw status, the graph type, and other general settings for each of the graphs in the graph menu (GPH1, GPH2, GPH3).

- **Mark Type**

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

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

Pressing F1(GRPH) 5(Set) displays the general graph settings screen.



```
StatGraph1
Graph Type    :Scatter
XList         :List1
YList         :List2
Frequency     :1
Mark Type     :□

GPH1 GPH2 GPH3
```

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

- **StatGraph (statistical graph specification)**
  - {**GPH1**}/{**GPH2**}/{**GPH3**} ... graph {1}/{2}/{3}

- **Graph Type (graph type specification)**
  - {**Scat**}/{xy}/{**NPP**} ... {scatter diagram}/{xy line graph}/{normal probability plot}
  - {**Hist**}/{**Box**}/{**ModB**}/{**N·Dis**}/{**Brkn**} ... {histogram}/{med-box graph}/{modified-box graph}/{normal distribution curve}/{broken line graph}
  - {**X**}/{**Med**}/{**X^2**}/{**X^3**}/{**X^4**} ... {linear regression graph}/{Med-Med graph}/{quadratic regression graph}/{cubic regression graph}/{quartic regression graph}
  - {**Log**}/{**Exp**}/{**Pwr**}/{**Sin**}/{**Lgst**} ... {logarithmic regression graph}/{exponential regression graph}/{power regression graph}/{sinusoidal regression graph}/{logistic regression graph}

- **XList (x-axis data list)**
  - {**LIST**} ... {List 1 to 20}

- **YList (y-axis data list)**
  - {**LIST**} ... {List 1 to 20}

- **Frequency (number of times a value occurs)**
  - {**1**} ... {1-to-1 plot}
  - {**LIST**} ... contents of this list indicates the frequency of XList and YList data

- **Mark Type (plot mark type)**
  - {□}/{×}/{•} ... scatter diagram plot points

2. Graph draw/non-draw status **[GRPH]-[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. Pressing F1(GRPH) 4(Select) displays the graph On/Off screen.

```
StatGraph1  :DrawOn
StatGraph2  :DrawOff
StatGraph3  :DrawOff
```

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

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

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

3. To return to the graph menu, press ESC.

View Window parameters are normally set automatically for statistical graphing. If you want to set View Window parameters manually, you must change the Stat Wind item to “Manual”.
While the statistical data list is on the display, perform the following procedure.

CTRL F3(SET UP) F2(Man)

ESC(Returns to previous menu.)

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

Pressing CTRL 0 does not hide the menu while a statistical graph is on the display.

6-2 Calculating and Graphing Single-Variable Statistical Data

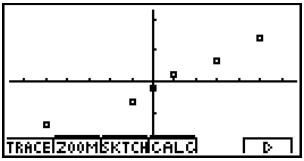
Single-variable data is data with only a single variable. If you are calculating the average height of the members of a class for example, there is only one variable (height).

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

You can also use the procedures under "Changing Graph Parameters" on page 6-1-2 to make the settings you want before drawing each graph.

■ Normal Probability Plot (NPP)

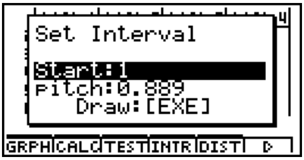
This plot compares the data accumulated ratio with a normal distribution accumulated ratio. XList specifies the list where data is input, and Mark Type is used to select from among the marks {□ / × / • }you want to plot.



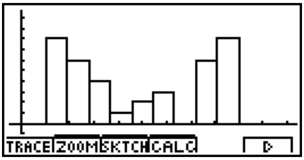
Press ESC or SHIFT ESC (QUIT) to return to the statistical data list.

■ Histogram (Bar Graph) (Hist)

XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.


Set Interval
Start:1
pitch:0.889
Draw:[EXE]

⇒
EXE (Draw)

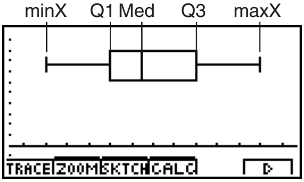


The display screen appears as shown above before the graph is drawn. At this point, you can change the Start and pitch values.

■ Med-box or Box and Whisker Graph (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 first quartile (Q1) to the third quartile (Q3), with a line drawn at the median (Med). Lines (called whiskers) extend from either end of the box up to the minimum (minX) and maximum (maxX) of the data.

XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.

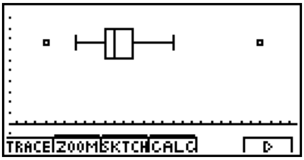


■ Modified Box Graph (ModB)

The modified box graph omits everything in the range past 1.5 × IQR (IQR = Q3 – Q1, Q3: 3rd quartile, Q1: 1st quartile) from the med-box 4th quartile and draws whiskers.

Outliers are displayed as plot points.

XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.



Input a positive integer for frequency data. Other types of values (decimals, etc.) cause an error.

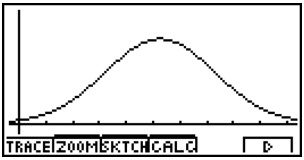
Dimension ERROR usually occurs when two lists contain a different number of elements.

Normal Distribution Curve (N•Dis)

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

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

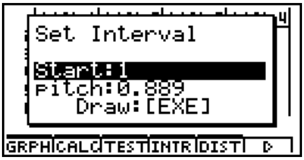
XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.



Broken Line Graph (Brkn)

Lines connect center points of a histogram bar.

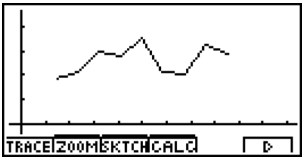
XList specifies the list where the data is input, while Freq specifies the list where the data frequency is input. 1 is specified for Freq when frequency is not specified.



Set Interval

Start:1
pitch:0.889
Draw:[EXE]

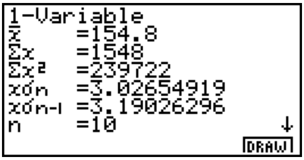
⇒
EXE (Draw)



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

Displaying the Calculation Results of a Drawn Single-Variable Graph

Single-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the single-variable calculation results appear as shown below when you press F4(CALC) 1(1VAR).



```
1-Variable
x̄      =154.8
Σx     =1548
Σx²    =239722
xσn    =3.02654919
xσn-1  =3.19026296
n      =10        ↓
```

- 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
Σx	sum
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
maxX	maximum
Mod	mode
Mod : n	number of data mode items
Mod : F	data mode frequency

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

When Mod has multiple solutions, they are all displayed.

6-3 Calculating and Graphing Paired-Variable Statistical Data

■ Drawing a Scatter Diagram and *xy* Line Graph

Description

The following procedure plots a scatter diagram and connects the dots to produce an *xy* line graph.

Set Up

1. From the Main Menu, enter the STAT Mode.

Execution

2. Input the data into a list.
3. Specify Scat (scatter diagram) or *xy* (*xy* line graph) as the graph type, and then execute the graph operation.

Press ESC or SHIFT ESC (QUIT) to return to the statistical data list.

● ● ● ● ●

Example **Input the two sets of data shown below. Next, plot the data on a scatter diagram and connect the dots to produce an *xy* line graph.**

0.5, 1.2, 2.4, 4.0, 5.2, (*x*List)

–2.1, 0.3, 1.5, 2.0, 2.4 (*y*List)

Procedure

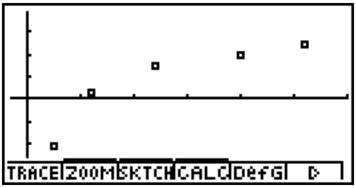
① MENU STAT

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

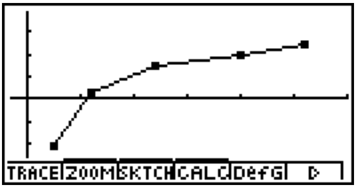
③ (Scatter diagram) F1 (GRPH) 5 (Set) ▼ F1 (Scat) ESC
F1 (GRPH) 1 (S-Gph1)

③ (*xy* line graph) F1 (GRPH) 5 (Set) ▼ F2 (*xy*) ESC
F1 (GRPH) 1 (S-Gph1)

Result Screen



(Scatter diagram)



(*xy* line graph)

Drawing a Regression Graph

Description

Use the following procedure to input paired-variable statistical data, perform a regression calculation using the data, and then graph the results.

Set Up

1. From the Main Menu, enter the STAT Mode.

Execution

2. Input the data into a list, and plot the scatter diagram.
3. Select the regression type, execute the calculation, and display the regression parameters.
4. Draw the regression graph.

You can perform trace on a regression graph.
You cannot perform trace scroll.

● ● ● ● ●

Example **Input the two sets of data shown below and plot the data on a scatter diagram. Next, perform logarithmic regression on the data to display the regression parameters, and then draw the corresponding regression graph.**

0.5, 1.2, 2.4, 4.0, 5.2, (*x*List)
–2.1, 0.3, 1.5, 2.0, 2.4 (*y*List)

Procedure

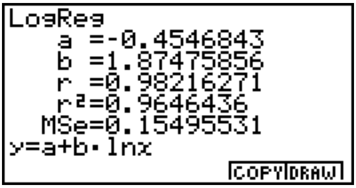
① MENU STAT

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
F1 (GRPH) 5 (Set) ▼ F1 (Scat) ESC
F1 (GRPH) 1 (S-Gph1)

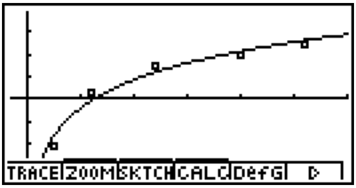
③ F4 (CALC) 7 (Log)

④ F6 (DRAW)

Result Screen



```
LogReg
   a =-0.4546843
   b =1.87475856
   r =0.98216271
   r²=0.9646436
  MSe=0.15495531
y=a+b·lnx
```



Selecting the Regression Type

After you graph paired-variable statistical data, press F4 (CALC). Then you can use the function menu at the bottom of the display to select from a variety of different types of regression.

- {**2VAR**} ... {paired-variable statistical results}
- {**Linear**}/{**MedMed**}/{**Quad**}/{**Cubic**}/{**Quart**}/{**Log**}/{**Exp**}/{**Power**}/{**Sin**}/{**Lgstic**}
  ... {linear regression}/{Med-Med}/{quadratic regression}/{cubic regression}/{quartic regression}/{logarithmic regression}/{exponential regression}/{power regression}/{sinusoidal regression}/{logistic regression} calculation and graphing

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.

Graphing Statistical Calculation Results

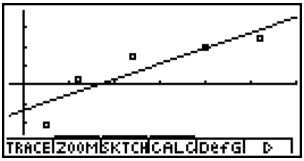
While the parameter calculation result is on the display, you can graph the displayed regression formula by pressing F6 (DRAW).

Linear Regression Graph

Linear regression uses the method of least squares to plot 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.

F4(CALC) 2(Linear)
F6(DRAW)



The following is the linear regression model formula.

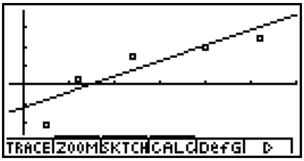
$y = ax + b$

a .... regression coefficient (slope)
b .... regression constant term (y-intercept)
r .... correlation coefficient
r^2 .... coefficient of determination
MSe .... mean square error

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 similar to linear regression, but it minimizes the effects of extreme values.

F4(CALC) 3(MedMed)
F6(DRAW)



The following is the Med-Med graph model formula.

$y = ax + b$

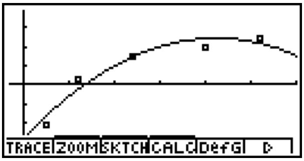
a .... Med-Med graph slope
b .... Med-Med graph y-intercept

Input a positive integer for frequency data.
Other types of values (decimals, etc.) cause an error.

Quadratic/Cubic/Quartic Regression Graph

A quadratic/cubic/quartic regression graph represents connection of the data points of a scatter diagram. It uses the method of least squares to draw a curve that passes close to as many data points as possible. The formula that represents this is quadratic/cubic/quartic regression.

Ex. Quadratic regression
F4(CALC) 4(Quad)
F6(DRAW)



Quadratic regression

Model formula ..... $y = ax^2 + bx + c$
a .... regression second coefficient
b .... regression first coefficient
c .... regression constant term (y-intercept)
r^2 .... coefficient of determination
MSe .... mean square error

Cubic regression

Model formula ..... $y = ax^3 + bx^2 + cx + d$
a .... regression third coefficient
b .... regression second coefficient
c .... regression first coefficient
d .... regression constant term (y-intercept)
r^2 .... coefficient of determination
MSe .... mean square error

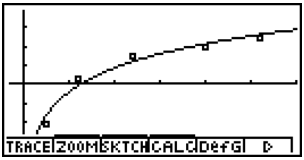
Quartic regression

Model formula ..... $y = ax^4 + bx^3 + cx^2 + dx + e$
a .... regression fourth coefficient
b .... regression third coefficient
c .... regression second coefficient
d .... regression first coefficient
e .... regression constant term (y-intercept)
r^2 .... coefficient of determination
MSe .... mean square error

Logarithmic Regression Graph

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

F4(CALC) 7(Log)
F6(DRAW)



The following is the logarithmic regression model formula.

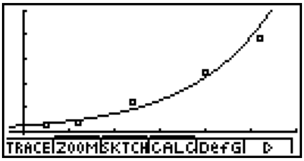
$$y = a + b \cdot \text{In}\, x$$

a .... regression constant term
b .... regression coefficient
r .... correlation coefficient
r^2 .... coefficient of determination
MSe .... mean square error

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 $\text{In}\, y = \text{In}\, a + bx$. Next, if we say $\text{Y} = \text{In}\, y$, and $\text{A} = \text{In}\, a$, the formula corresponds to linear regression formula $\text{Y} = \text{A} + bx$.

F4(CALC) 8(Exp)
F6(DRAW)



The following is the exponential regression model formula.

$$y = a \cdot e^{bx}$$

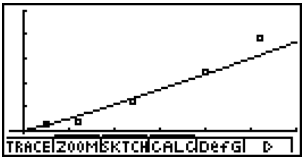
a .... regression coefficient
b .... regression constant term
r .... correlation coefficient
r^2 .... coefficient of determination
MSe .... mean square error

■ Power Regression Graph

Power 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 logarithm of both sides we get In y = In a + $b \times$ In x. Next, if we say X = In x, Y = In y, and A = In a, the formula corresponds to linear regression formula Y = A + bX.

F4(CALC) 9(Power)

F6(DRAW)



The following is the power regression model formula.

$$y = a \cdot x^b$$

a .... regression coefficient

b .... regression power

r .... correlation coefficient

r^2 .... coefficient of determination

MSe .... mean square error

■ Sinusoidal Regression Graph

Sinusoidal regression is best applied for cyclical data.

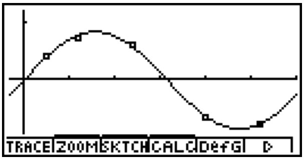
The following is the sinusoidal regression model formula.

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

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

F4(CALC) X,θ,T(Sin)

F6(DRAW)



Drawing a sinusoidal regression graph causes the angle unit setting of the calculator to automatically change to Rad (radians). The angle unit does not change when you perform a sinusoidal regression calculation without drawing a graph.

- Certain types of data may take a long time to calculate. This does not indicate malfunction.

Logistic Regression Graph

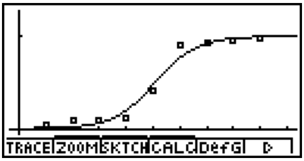
Logistic regression is best applied for time-based phenomena in which there is a continual increase until a saturation point is reached.

The following is the logistic regression model formula.

$$y = \frac{c}{1 + ae^{-bx}}$$

F4(CALC) log(Lgstic)

F6(DRAW)



- Certain types of data may take a long time to calculate. This does not indicate malfunction.

Residual Calculation

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

While the statistical data list is on the display, recall the SET UP screen to specify a LIST ("List 1" through "List 20") for "Resid List". Calculated residual data is stored in the specified list.

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

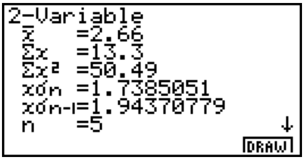
Plots that are higher than the regression model are positive, while those that are lower are negative.

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

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

Displaying the Calculation Results of a Drawn Paired-Variable Graph

Paired-variable statistics can be expressed as both graphs and parameter values. When these graphs are displayed, the paired-variable calculation results appear as shown below when you press F4(CALC) 1(2VAR).



```
2-Variable
 x̄    =2.66
 Σx   =13.3
 Σx²  =50.49
 xσn  =1.7385051
 xσn-1=1.94370779
 n    =5            ↓
                 DRAW
```

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

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

Copying a Regression Graph Formula to the GRPH•TBL Mode

You can copy regression formula calculation results to the GRPH•TBL Mode graph formula area, and store and compare.

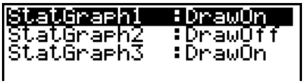
1. Press F5(COPY) to copy the regression formula that produced the displayed data to the GRPH•TBL Mode graph formula area*[1].
2. Press EXE to save the copied graph formula and return to the previous regression calculation result display.

---

[1] You cannot edit regression formulas for graph formulas in the GRPH•TBL Mode.

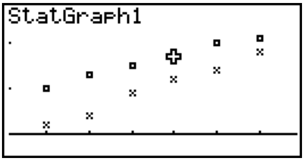
Multiple Graphs

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)(see page 6-1-4). 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
```

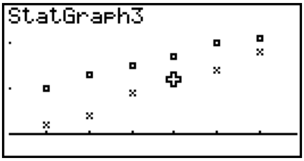
F4(CALC)
2(Linear)



StatGraph1

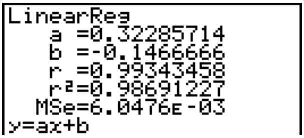
- The text at the top of the screen indicates the currently selected graph (StatGraph1 = Graph 1, StatGraph2 = Graph 2, StatGraph3 = Graph 3).

1. Press ⊙. The graph name at the top of the screen changes when you do.



StatGraph3

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



```
LinearReg
   a =0.32285714
   b =-0.1466666
   r =0.99343458
   r²=0.98691227
  MSe=6.0476E-03
y=ax+b
```

Now you can use the procedure under "Displaying the Calculation Results of a Drawn Paired-Variable Graph" on page 6-3-11 to perform statistical calculations.

Overlaying a Function Graph on a Statistical Graph

Description

You can overlay a paired-variable statistical graph with any type of function graph you want.

Set Up

1. From the Main Menu, enter the STAT Mode.

Execution

2. Input the data into a list, and draw the statistical graph.
3. Display the Graph Function menu, and input the function you want to overlay on the statistical graph.
4. Graph the function.

● ● ● ● ●

Example **Input the two sets of data shown below. Next, plot the data on a scatter diagram and overlay a function graph y = 2ln x.**

0.5, 1.2, 2.4, 4.0, 5.2,

–2.1, 0.3, 1.5, 2.0, 2.4

Procedure

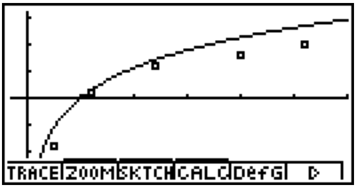
① [MENU] STAT

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]
[F1] (GRPH) [1] (S-Gph1)

③ [F5] (DefG)
[2] [ln] [X,θ,T] [EXE] (Register Y1 = 2ln x)

④ [F6] (DRAW)

Result Screen



You can also perform trace, etc. for drawn function graphs.
Graphs of types other than rectangular coordinate graphs cannot be drawn.

Pressing [ESC] while inputting a function returns the expression to what it was prior to input. Pressing [SHIFT] [ESC] (QUIT) clears the input expression and returns to the statistical data list.

6-4 Performing Statistical Calculations

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

• To specify statistical calculation data lists

You have to input the statistical data for the calculation you want to perform and specify where it is located before you start a calculation. Display the statistical data and then press F2 (CALC) 4 (Set).

```
1Var XList  :List1
1Var Freq   :1
2Var XList  :List1
2Var YList  :List2
2Var Freq   :1

LIST
```

The following is the meaning for each item.

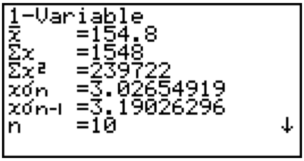
1Var XList	location of single-variable statistic x values (XList)
1Var Freq	location of single-variable frequency values (Frequency)
2Var XList	location of paired-variable statistic x values (XList)
2Var YList	location of paired-variable statistic y values (YList)
2Var Freq	location of paired-variable frequency values (Frequency)

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

Single-Variable Statistical Calculations

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

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



```
1-Variable
x̄      =154.8
Σx     =1548
Σx²    =239722
xσn    =3.02654919
xσn-1  =3.19026296
n      =10          ↓
```

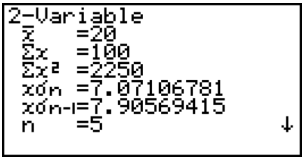
After this, pressing ▲ or ▼ scrolls the statistical calculation result display so you can view variable characteristics.

For details on the meanings of these statistical values, see “Displaying the Calculation Results of a Drawn Single-Variable Graph” (page 6-2-4).

Paired-Variable Statistical Calculations

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

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



```
2-Variable
 x̄     =20
 Σx    =100
 Σx²   =2250
 xσn   =7.07106781
 xσn-1=7.90569415
 n     =5           ↓
```

After this, pressing ▲ or ▼ scrolls the statistical calculation result display so you can view variable characteristics.

For details on the meanings of these statistical values, see “Displaying the Calculation Results of a Drawn Paired-Variable Graph” (page 6-3-11).

Regression Calculation

In the explanations from “Linear Regression Graph” to “Logistic Regression Graph,” regression calculation results were displayed after the graph was drawn. Here, each coefficient value of the regression line and regression curve is expressed as a number.

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

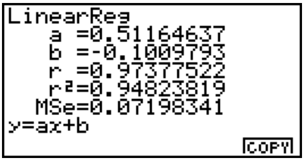
Pressing F2(CALC) 3(REG) displays the pull-up menu, which contains the following items.

- {**Linear**}/{**MedMed**}/{**Quad**}/{**Cubic**}/{**Quart**}/{**Log**}/{**Exp**}/{**Power**}/{**Sin**}/{**Lgstic**} ... {linear regression}/{Med-Med}/{quadratic regression}/{cubic regression}/{quartic regression}/{logarithmic regression}/{exponential regression}/{power regression}/{sinusoidal regression}/{logistic regression} parameters

● ● ● ● ●

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

F2(CALC) 3(REG) 1(Linear)



```
LinearReg
    a =0.51164637
    b =-0.1009793
    r =0.97377522
    r²=0.94823819
  MSe=0.07198341
y=ax+b
```

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

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

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

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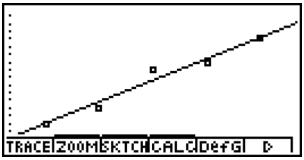
Example **To perform a linear regression using the nearby data and estimate the values of $\hat{y}$ and $\hat{x}$ when xi = 20 and yi = 1000**

xi	yi
10	1003
15	1005
20	1010
25	1011
30	1014

1. From the Main Menu, enter the STAT Mode.

2. Input data into the list and draw the linear regression graph.



3. From the Main Menu, enter the RUN • MAT Mode.

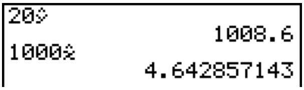
4. Press the keys as follows.

2 0 (value of xi)
OPTN F6 (▷) F4 (STAT) 2 ($\hat{y}$) EXE

```
20ŷ
            1008.6
```

The estimated value $\hat{y}$ is displayed for xi = 20.

1 0 0 0 (value of yi)
F4 (STAT) 1 ($\hat{x}$) EXE



```
20ŷ
            1008.6
1000x̂
       4.642857143
```

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

You cannot obtain estimated values for a Med-Med, quadratic regression, cubic regression, quartic regression, sinusoidal regression, or logistic regression graph.

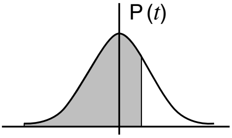
Normal Probability Distribution Calculation

You can calculate normal probability distributions for single-variable statistics with the RUN • MAT Mode.

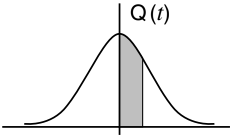
Press OPTN F6 (▷) F1 (PROB) to display a function menu, which contains the following items.

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

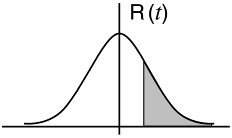
- Normal probability P(t), Q(t), and R(t), and normalized variate $t(x)$ are calculated using the following formulas.



$$\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{t} e^{-\frac{u^2}{2}}du$$



$$\frac{1}{\sqrt{2\pi}}\int_{0}^{t} e^{-\frac{u^2}{2}}du$$



$$\frac{1}{\sqrt{2\pi}}\int_{t}^{+\infty} e^{-\frac{u^2}{2}}du$$

$$t(x)=\frac{x-\bar{x}}{x\sigma_n}$$

• • • • •

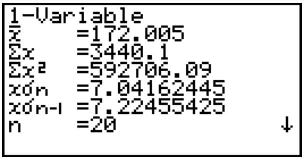
Example **The following table shows the results of measurements of the height of 20 college students. Determine what percentage of the students fall in the range 160.5 cm to 175.5 cm. Also, in what percentile does the 175.5 cm tall student fall?**

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. Input the height data into List 1 and the frequency data into List 2.

2. Perform the single-variable statistical calculations.[1]

F2(CALC) 4(Set)
F1(LIST) 1 EXE
▼ F2(LIST) 2 EXE ESC
F2(CALC) 1(1VAR)



```
1-Variable
x̄     =172.005
Σx    =3440.1
Σx²   =592706.09
xσn   =7.04162445
xσn-1 =7.22455425
n     =20             ↓
```

3. Press MENU, select the RUN • MAT Mode, press OPTN F6(▷) F1(PROB) to recall the probability calculation (PROB) menu.

F1(PROB) 8(*t*() 1 6 0 • 5) EXE
(Normalized variate *t* for 160.5cm) Result: –1.633855948
(≒ –1.634)

F1(PROB) 8(*t*() 1 7 5 • 5) EXE
(Normalized variate *t* for 175.5cm) Result: 0.4963343361
(≒ 0.496)

F1(PROB) 5(P() 0 • 4 9 6) −
F1(PROB) 5(P() (–) 1 • 6 3 4) EXE
(Percentage of total) Result: 0.638921
(63.9% of total)

F1(PROB) 7(R() 0 • 4 9 6) EXE
(Percentile) Result: 0.30995
(31.0 percentile)

---

[1] You can obtain the normalized variate immediately after performing single-variable statistical calculations only.

■ Drawing a Normal Probability Distribution Graph

Description

You can draw a normal probability distribution graph using manual graphing with the RUN • MAT Mode.

Set Up

1. From the Main Menu, enter the RUN • MAT Mode.

Execution

2. Input the commands to draw a rectangular coordinate graph.
3. Input the probability value.

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Example **To draw a normal probability P (0.5) graph.**

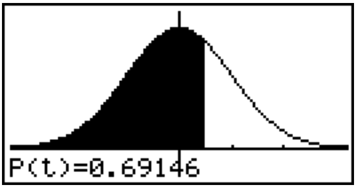
Procedure

① MENU RUN • MAT

② OPTN F6 (▷) F6 (▷) F2 (SKTCH) 1 (Cls) EXE
F2 (SKTCH) 4 (GRPH) 1 (Y=)

③ OPTN F6 (▷) F1 (PROB) 5 (P() 0 • 5 EXE

Result Screen



P(t)=0.69146

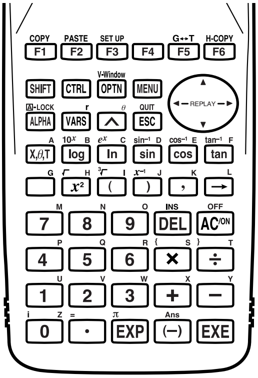
Chapter 7

Computer Algebra System and Tutorial Modes (ALGEBRA FX 2.0 PLUS only)

7-1 Using the CAS (Computer Algebra System) Mode

On the Main Menu, select the **CAS** icon to enter the CAS Mode.

The following table shows the keys that can be used in the CAS Mode.

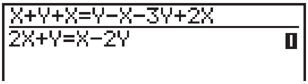


Inputting and Displaying Data

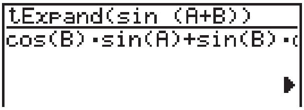
Input in the Algebra Mode is performed in the upper part of the display, which is called the "input area." You can input commands and expressions at the current cursor location.


X+Y+X=Y-X-3Y+2X

Calculation results appear in the lower part of the display, which is called the "output area." When a calculation produces an equation or inequality, the lower part of the display is divided between a "natural result display area" for the result, and a "formula number area" for the formula number as shown below.


X+Y+X=Y-X-3Y+2X
2X+Y=X-2Y

If all the result does not fit on the display, use the cursor keys to scroll it.



```
tExpand(sin (A+B))
cos(B)·sin(A)+sin(B)·(
```

Inputting List Data

List: {element, element, ..., element}

- Elements should be separated by commas, and the entire set of elements should be enclosed within {curly braces}.
- You can input numeric values and expressions, equations, and inequalities as list elements.

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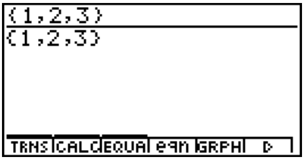
Example **To input List {1, 2, 3}**

SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) EXE



```
{1,2,3}
{1,2,3}
```

Inputting Matrix Data

Matrix ($m \times n$): [[(1,1) entry, (1,2) entry, ..., (1,m) entry] [(2,1) entry, ..., (2,n) entry]...
[(m, n) entry, ..., (m, n) entry]]

- The above input is arranged to show the relative positions of entries in the matrix. Actual input is an unbroken line, from left to right.
- Entries should be separated by commas, and the entire set of elements should be enclosed within [square brackets]. And each line also should be enclosed within [square brackets].
- You can input numeric values and expressions as matrix entries.

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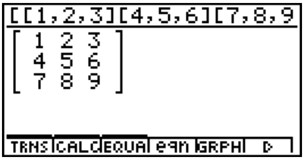
Example **To input the matrix shown below** $\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$

SHIFT + ([ ) SHIFT + ([ ) 1 , 2 , 3
SHIFT − ( ]) SHIFT + ([ ) 4 , 5 , 6
SHIFT − ( ]) SHIFT + ([ ) 7 , 8 , 9
SHIFT − ( ]) SHIFT − ( ]) EXE



```
[[1,2,3][4,5,6][7,8,9
[ 1 2 3 ]
[ 4 5 6 ]
[ 7 8 9 ]
```

Inputting Vector Data

Vector: [component, component, ..., component]

- Components should be separated by commas, and the entire set of components should be enclosed within [square brackets].
- You can input numeric values and expressions as vector component entries.

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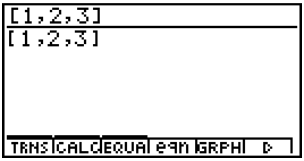
Example **To input Vector (1 2 3)**

SHIFT + ([ ) 1 , 2 , 3

SHIFT − ( ]) EXE


[1,2,3]
[1,2,3]

Performing an Algebra Mode Operation

There are two methods that you can use for input in the Algebra Mode.

- Function menu command input
- Manual formula and parameter input

Menu Command Input

Press a function menu key to display the menu of functions for the type of operation you are trying to perform.

- **TRNS** ... {formula transformation menu}
- **CALC** ... {formula calculation menu}
- **EQUA** ... {equation, inequality menu}
- **eqn** ... {calls up an equation stored in Equation Memory in accordance with a specified input value}
- **CLR** ... {variable/formula delete menu}

Pressing the OPTN key displays the menu shown below.

- **LIST** ... {list calculation menu}
- **MAT** ... {matrix calculation menu}
- **VECT** ... {vector calculation menu}

For details on commands and their formats, see the “Algebra Command Reference” on page 7-1-11.

Manual Formula and Parameter Input

You can use the function menus, OPTN key, and VARS key in combination to input formulas and parameters as described below.

- F3 (EQUA) 1 (INEQUA)
  - {>}/{<}/{≥}/{≤} ... {inequality}
- OPTN key
  - {∞}/{**Abs**}/{**x!**}/{**sign**} ... {infinity}/{absolute value}/{factorial}/{signum function*[1]}
  - {**HYP**} ... {hyperbolic}/{inverse hyperbolic} functions
    - **{sinh}/{cosh}**/{**tanh**}/{**sinh^{-1}**}/{**cosh^{-1}**}/{**tanh^{-1}**}
- VARS key
  - {**Yn**}/{**rn**}/{**Xtn**}/{**Ytn**}/{**Xn**} ... input of graph memory {Yn}/{rn}/{Xtn}/{Ytn}/{Xn}

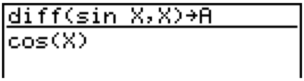
Formula Memory

The CAS Mode has 28 formula variables. Variable names are the letters A through Z, plus r, and θ. CAS Mode formula variables are independent of standard value variables.

• • • • •

Example **To assign a formula that differentiates sin(X) at X (cos(X)) to variable A**

F2 (CALC) 1 (diff) sin X,θ,T ,
X,θ,T) → ALPHA X,θ,T (A) EXE



```
diff(sin X,X)→A
cos(X)
```

---

[1] $signum\,(A) \begin{cases} 1 \text{ (real number, } A > 0) \\ -1 \text{ (real number, } A < 0) \\ \dfrac{A}{|A|} \text{ (}A\text{= imaginary number)} \\ \text{Undefined } (A = 0) \end{cases}$

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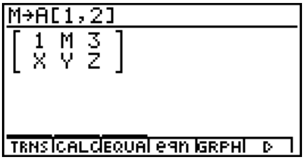
Example **To assign M to row 1 column 2 of variable A when the matrix $\begin{bmatrix}1&2&3\\X&Y&Z\end{bmatrix}$ is assigned to it**

ALPHA 7 (M) → ALPHA X,θ,T (A)
SHIFT + ([ ) 1 , 2 SHIFT − ( ]) EXE


M→A[1,2]
$\begin{bmatrix}1&M&3\\X&Y&Z\end{bmatrix}$

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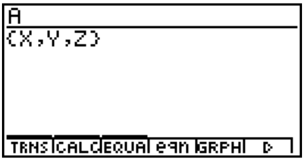
Example **To recall the value of variable A when the list {X, Y, Z} is assigned to it**

ALPHA X,θ,T (A) EXE


A
{X,Y,Z}

● ● ● ● ●

Example **To recall the first component (A [1]) of variable A when vector (X Y Z) is assigned to it**

ALPHA X,θ,T (A) SHIFT + ([ ) 1
SHIFT − ( ]) EXE


A[1]
X

Function Memory and Graph Memory

Function memory lets you store functions for later recall when you need them.

With graph memory, you can store graphs in memory. Press the VARS key and then input the name of the graph.

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Example **To differentiate f_1 = cos(X), which is assigned to function memory f_1, at X**

F2(CALC) 1(diff) OPTN F6(▷) F4(FMEM)
3(fn) 1 , X,θ,T) EXE

```
diff(fn1,X)
-sin(X)
```

● ● ● ● ●

Example **To differentiate Y1 = cos(X), which is assigned to graph memory Y1, at X**

F2(CALC) 1(diff)
VARS F1(Yn) 1 , X,θ,T) EXE

```
diff(Y1,X)
-sin(X)
```

Eqn Memory

When a calculation result is an equation or inequality, its formula number is displayed in the formula number area, and the equation is stored in Eqn memory.*1 Stored equations can be recalled with the eqn command, rclEqn command or rclAllEqn command.

*1 Up to 99 formulas can be stored in Eqn memory.
The error message "Memory ERROR" when you try to store an equation when there are already 99 equations in Eqn memory. When this happens, execute the ALLEQU (Delete All Equations) from the CLR menu.

Answer (Ans) Memory and Continuous Calculation

Answer (Ans) memory and continuous calculation can be used just as with standard calculations. In the Algebra Mode, you can even store formulas in Ans memory.

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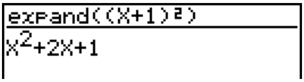
Example **To expand $(X+1)^2$ and add the result to 2X**

F1 (TRNS) 1 (expand)

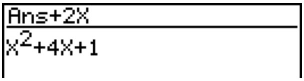
(X,θ,T + 1) x^2) EXE



```
expand((X+1)²)
X²+2X+1
```

Continuing:

+ 2 X,θ,T EXE



```
Ans+2X
X²+4X+1
```

Replay Contents

Replay memory can be used in the input area. After a calculation is complete, pressing ◀ or ▶ in the input area recalls the formula of the last calculation performed. After a calculation or after pressing AC, you can press ▲ or ▼ to recall previous formulas.

Moving the Cursor Between Display Areas

When ◀ ▶ ▲ ▼ indicates a calculation result that does not fit on the display, the cursor keys perform output area scrolling. To use the Replay Function from this condition, press F6 (▷) F2 (SW). ◀ ▶ ▲ ▼ change to a dotted line display to indicate that cursor key operations control the input area.

Pressing F2 (SW) again moves the cursor back to the output area.

Pressing F6 (▷) F1 (CLR) 3 (ALLEQU) deletes Eqn memory, Ans memory, and Replay memory contents.

You can input up to 255 bytes of data into the input area.

SET UP Items

- **Angle** ... Unit of angular measurement specification
  - {**Deg**}/{**Rad**} ... {degrees}/{radians}
- **Answer Type** ... Result range specification
  - {**Real**}/{**Cplx**} ... {real number}/{complex number}
- **Display** ... Display format specification (for approx only)
  - {**Fix**}/{**Sci**}/{**Norm**} ... {number of decimal places}/{number of significant digits}/ {normal display format}

■ Graph Function

Pressing F5(GRPH) displays the graph formula screen, which you can use to input a graph formula. Press F4(G•VAR) if you want to input a graph memory.
You can also use the F1(SEL), F2(DEL), and F3(TYPE) functions while the graph formula screen is on the display.

Press F6(DRAW) to draw a graph.

■ RECALL ANS Function

Pressing F6(▷)F3(R•ANS) recalls Ans Memory contents.

■ Solution Memory

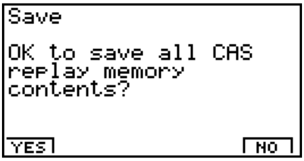
In the CAS Mode or ALGEBRA Mode, you can save the history of a calculation you perform (replay memory contents) into solution memory. This section describes how you can access and work with the contents of solution memory. Pressing F6(▷)F4(MEM) on the CAS Mode or ALGEBRA Mode main menu display the initial solution memory screen shown below.

Solution Memory
F1:Save
F2:Clear Memory
F3:Optimization
F6:Display Memory

- {**SAVE**} ... {saves the calculation history to solution memory}
- {**DEL•A**}... {deletes solution memory contents}
- {**OPT**} ... {optimizes solution memory}
- {**DISP**} ... {displays solution memory contents}

• To save a calculation history to solution memory (Save)

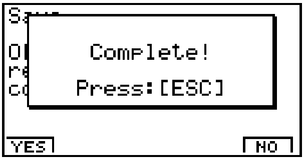
On the initial solution memory screen, press F1(SAVE).



Save

OK to save all CAS replay memory contents?

Press F1(YES) to save the calculation history to solution memory.



Complete!

Press:[ESC]

Pressing ESC returns to the solution memory initial screen.

- Pressing F6(NO) in place of F1(YES) returns to the solution memory initial screen without saving anything.

• To clear solution memory contents (Clear Memory)

On the initial solution memory screen, press F2(DEL·A).

Clear Memory

OK to clear CAS and ALG all data in solution memories?

Press F1(YES) to clear solution memory contents.

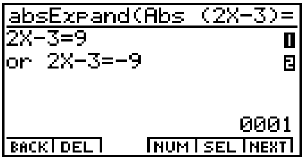
Pressing ESC returns to the solution memory initial screen.

- Pressing F6(NO) in place of F1(YES) returns to the solution memory initial screen without clearing anything.
- This clears both CAS Mode and ALGEBRA Mode memory contents. You cannot select the mode shows memory contents you want to delete.

• To display solution memory contents (Display Memory)

On the initial solution memory screen, press F6(DISP).

This displays the oldest expression and result in solution memory. The bottom line shows the record number.



```
absExpand(Abs (2X-3)=
2X-3=9
or 2X-3=-9
                 0001
```

- F6(DISP) is disabled when there is no data in Solution memory.

• To display the next record

Press F6(NEXT).

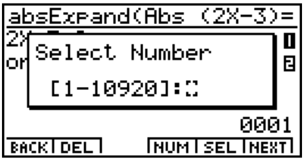
• To display the previous record

Press F1(BACK).

- Pressing F1(BACK) while the oldest record is on the display returns to the solution memory initial screen.

• To display a particular record

Press F5(SEL) and then input the number of the record you want to display.



```
absExpand(Abs (2X-3)=
Select Number
[1-10920]:
                 0001
```

Pressing EXE displays the record whose number you input.

• To delete a single solution memory record

Display the record you want to delete, and then press F2(DEL).

In response to the confirmation message that appears, press EXE(Yes) to delete the record you displayed.

To clear the above screen without deleting anything, press ESC(No).

• To toggle record number display on and off

Press F4(NUM) to toggle display of the record number on and off.

• To optimize solution memory (Optimization)

On the initial solution memory screen, press F3(OPT).

Pressing ESC returns to the solution memory initial screen.

Optimizing solution memory rearranges data and can free up more storage space. Perform the above procedure when solution memory capacity starts running low.

Algebra Command Reference

The following are the abbreviations used in this section.

- **Exp** ... Expression (value, formula, variable, etc.)
- **Eq** ... Equation
- **Ineq** ... Inequality
- **List** ... List
- **Mat** ... Matrix
- **Vect** ... Vector

Anything enclosed within square brackets can be omitted.

• expand

Function: Expands an expression.

Syntax: expand ({Exp/Eq/Ineq/List/Mat/Vect} [ )]

● ● ● ● ●

Example **To expand $(X+2)^2$**

F1 (TRNS) 1 (expand) (X,θ,T + 2) x^2 EXE **$X^2 + 4X + 4$**

• rFactor (rFctor)

Function: Factors an expression up to its root.

Syntax: rFactor ({Exp/Eq/Ineq/List/Mat/Vect} [ )]

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Example **To factor the $X^2 - 3$**

F1 (TRNS) 2 (rFctor) X,θ,T x^2 − 3 EXE **$(X - \sqrt{3})\ (X + \sqrt{3})$**

• factor

Function: Factors an expression.

Syntax: factor ({Exp/Eq/Ineq/List/Mat/Vect} [ )]

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Example **To factor $X^2 - 4X + 4$**

F1 (TRNS) 3 (factor) X,θ,T x^2 − 4 X,θ,T + 4 EXE **$(X - 2)^2$**

• solve

Function: Solves an equation.

Syntax: solve(Eq [,variable] [ )]

solve({Eq-1,..., Eq-n}, {variable-1,...,variable-n} [ )]

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Example **To solve AX + B = 0 for X**

F1 (TRNS) 4 (solve) ALPHA X,θ,T (A) X,θ,T +
ALPHA log (B) SHIFT . (=) 0 EXE

$$X = \frac{-B}{A}$$

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Example **To solve simultaneous linear equation 3X + 4Y = 5, 2X – 3Y = – 8**

F1 (TRNS) 4 (solve) SHIFT × ({)
3 ALPHA + (X) + 4 ALPHA − (Y) SHIFT . (=) 5 ,
2 ALPHA + (X) − 3 ALPHA − (Y) SHIFT . (=) (−) 8
SHIFT ÷ (}) , SHIFT × ({) ALPHA + (X) ,
ALPHA − (Y) SHIFT ÷ (}) EXE

X = – 1
Y = 2

• X is the default when no variable is specified.

• tExpand (tExpnd)

Function: Employs the addition theorem to expand a trigonometric function.

Syntax: tExpand({Exp/List/Mat/Vect} [ )]

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Example **To employ the addition theorem to expand sin(A+B)**

F1 (TRNS) 5 (TRIG) 1 (tExpnd)
sin (ALPHA X,θ,T (A) + ALPHA log (B) EXE

cos(B) • sin(A) + sin(B) • cos(A)

• tCollect (tCollc)

Function: Employs the addition theorem to transform the product of a trigonometric function to a sum.

Syntax: tCollect({Exp/List/Mat/Vect} [ )]

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Example **To employ the addition theorem to transform sin(A)cos(B) to trigonometric sum**

F1 (TRNS) 5 (TRIG) 2 (tCollc)
sin ALPHA X,θ,T (A) cos ALPHA log (B) EXE

$$\frac{\sin(A+B)}{2} + \frac{\sin(A-B)}{2}$$

• trigToExp (trigToE)

Function: Transforms a trigonometric or hyperbolic function to an exponential function.

Syntax: trigToExp({Exp/List/Mat/Vect} [ )]

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Example **To convert cos(iX) to an exponential function**

F1(TRNS) 5(TRIG) 3(trigToE) cos SHIFT 0(*i*) X,θ,T EXE

$$\frac{e^{X}+e^{-X}}{2}$$

• expToTrig (expToT)

Function: Converts an exponential function to a trigonometric or hyperbolic function.

Syntax: expToTrig({Exp/List/Mat/Vect} [ )]

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Example **To convert e^{iX} to a trigonometric function**

F1(TRNS) 5(TRIG) 4(expToT)
SHIFT ln(e^x) (SHIFT 0(*i*) X,θ,T EXE

cos(X) + sin(X) • i

• simplify (smplfy)

Function: Simplifies an expression.

Syntax: simplify({Exp/Eq/Ineq/List/Mat/Vect} [ )]

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Example **To simplify 2X + 3Y – X + 3 = Y + X – 3Y + 3 – X**

F1(TRNS) 6(smplfy) 2 ALPHA +(X) + 3 ALPHA −(Y)
− ALPHA +(X) + 3 SHIFT .(=) ALPHA −(Y)
+ ALPHA +(X) − 3 ALPHA −(Y) + 3 −
ALPHA +(X) EXE

X + 3Y + 3 = –2Y + 3

• combine (combin)

Function: Adds and reduces rational expressions.

Syntax: combine({Exp/Eq/Ineq/List/Mat/Vect} [ )]

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Example **To reduce the fraction (X + 1)/(X + 2) + X (X + 3)**

F1 (TRNS) 7 (combin) (X,θ,T + 1) ÷
(X,θ,T + 2) + X,θ,T (X,θ,T + 3 EXE

$$\frac{X^3 + 5X^2 + 7X + 1}{X + 2}$$

• collect (collct)

Function: Rearranges an expression, focusing on a particular variable.

Syntax: collect({Exp/Eq/Ineq/List/Mat/Vect} [,{Exp/variable}] [ )]

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Example **To rearrange X^2 + AX + BX, focusing on the variable X**

F1 (TRNS) 8 (collct) X,θ,T x^2 + ALPHA X,θ,T (A) X,θ,T +
ALPHA log (B) X,θ,T EXE

$$X^2 + (A + B)X$$

- X is the default when nothing is specified for [,{Exp/variable}].

• substitute (sbstit)

Function: Assigns an expression to a variable.

Syntax: substitute({Exp/Eq/Ineq/List/Mat/Vect}, variable=expression
[,..., variable=expression] [ )]

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Example **To assign 5 to X in 2X – 1**

F1 (TRNS) 9 (sbstit) 2 X,θ,T − 1 ,
X,θ,T SHIFT • (=) 5 EXE

9

• cExpand (cExpnd)

Function: Expands xth root of imaginary number.

Syntax: cExpand({Exp/Eq/Ineq/List/Mat/Vect} [ )]

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Example **To expand $\sqrt{2i}$**

F1 (TRNS) X,θ,T (cExpnd) SHIFT x^2 ($\sqrt{\ }$) 2 SHIFT 0 (i) EXE **1 + i**

• approx

Function: Produces a numerical approximation for an expression.

Syntax: approx({Exp/Eq/Ineq/List/Mat/Vect} [ )]

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Example **To obtain a numerical value for $\sqrt{2}$**

F1 (TRNS) log (approx) SHIFT x^2 ($\sqrt{\ }$) 2 EXE **1.414213562**

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Example 9^{20}

Normal: 9 ^ 2 0 EXE **12157665459056928801**

approx: F1 (TRNS) log (approx) 9 ^ 2 0 EXE **1. 215766546E+19 (Display: Norm1)**

About approx

With normal calculations (when approx is not used) in the CAS Mode, calculation results are displayed in full, without using exponents. When you use approx in the CAS Mode, however, results are displayed using the exponential format range specified by the Display item of the SET UP screen.

This means approx displays results in the CAS Mode the same way they are displayed in the RUN • MAT Mode.

• diff

Function: Differentiates an expression.

Syntax: diff({Exp/List} [, variable, order, derivative] [ )]
diff({Exp/List}, variable [, order, derivative] [ )]
diff({Exp/List}, variable, order [, derivative] [ )]

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Example **To differentiate X^6 with respect to X**

F2 (CALC) 1 (diff) X,θ,T ^ 6 EXE **$6X^5$**

- X is the default when no variable is specified.
- 1 is the default when no order is specified.

• ∫

Function: Integrates an expression.

Syntax: ∫({Exp/List} [, variable, integration constant] [ )]
∫({Exp/List}, variable [, integration constant] [ )]
∫({Exp/List}, variable, lower limit, upper limit [ )]

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Example **To integrate X^2 with respect to X**

F2 (CALC) 2 (∫) X,θ,T x^2 EXE **$\frac{X^3}{3}$**

- X is the default when no variable is specified.

• lim

Function: Determines the limits of a function expression.

Syntax: lim({Exp/List}, variable, point [, direction] [ )]

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Example **To determine the limits of sin(X)/X when X = 0**

F2 (CALC) 3 (lim) sin X,θ,T ÷ X,θ,T , X,θ,T , 0 EXE **1**

- Direction can be positive (from right) or negative (from left).

- Σ

Function: Calculates a sum.

Syntax: Σ({Exp/List}, variable, start value, end value [ )]

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Example **To calculate the sum as the value of X in X^2 changes from X = 1 through X = 10**

F2 (CALC) 4 (Σ) X,θ,T x^2 , X,θ,T , 1 , 1 0 EXE **385**

- Π

Function: Calculates a product.

Syntax: Π({Exp/List}, variable, start value, end value [ )]

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Example **To calculate the product as the value of X in X^2 changes from X = 1 through X = 5**

F2 (CALC) 5 (Π) X,θ,T x^2 , X,θ,T , 1 , 5 EXE **14400**

- **taylor**

Function: Finds a Taylor polynomial.

Syntax: taylor({Exp/List}, variable, order [, center point] [ )]

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Example **To find a 5th order Taylor polynomial for sin(X) with respect to X = 0**

F2 (CALC) 6 (taylor) sin X,θ,T , X,θ,T , 5 , 0 EXE

$$\frac{X^5}{120} - \frac{X^3}{6} + X$$

- The default center point is zero.

- **arcLen**

Function: Returns the arc length.

Syntax: arcLen({Exp/List}, variable, start value, end value [ )]

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Example **To determine the arc length for X^2 from X = 0 to X = 1**

F2 (CALC) 7 (arcLen)
X,θ,T x^2 , X,θ,T , 0 , 1 EXE

$$\frac{\ln(4\sqrt{5}+8)}{4} - \frac{\ln(2)}{2} + \frac{\sqrt{5}}{2}$$

• tanLine (tanLin)

Function: Returns the expression for a tangent line.

Syntax: tanLine({Exp/List}, variable, variable value at point of tangency [ )]

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Example **To determine the expression for a line tangent with X^3 when X = 2**

F2 (CALC) 8 (tanLin) X,θ,T ^ 3 , X,θ,T , 2 EXE **12X – 16**

• denominator (den)

Function: Extracts the denominator of a fraction.

Syntax: denominator({Exp/List} [ )]

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Example **To extract the denominator of the fraction (X + 2)/(Y – 1)**

F2 (CALC) 9 (EXTRCT) 1 (den)
(ALPHA + (X) + 2) ÷ (ALPHA − (Y) − 1 EXE **Y – 1**

• numerator (num)

Function: Extracts the numerator of a fraction.

Syntax: numerator({Exp/List} [ )]

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Example **To extract the numerator of the fraction (X + 2)/(Y – 1)**

F2 (CALC) 9 (EXTRCT) 2 (num)
(ALPHA + (X) + 2) ÷ (ALPHA − (Y) − 1 EXE **X + 2**

• gcd

Function: Returns the greatest common divisor.

Syntax: gcd({Exp/List}, {Exp/List} [ )]

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Example **To determine the greatest common divisor of X + 1 and X^2 – 3X – 4**

F2 (CALC) X,θ,T (gcd) X,θ,T + 1 , X,θ,T x^2 −
3 X,θ,T − 4 EXE **X + 1**

• lcm

Function: Obtains the least common multiple of two expressions

Syntax: lcm({Exp/List}, {Exp/List} [ )]

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Example **To obtain the least common multiple of $X^2 - 1$ and $X^2 + 2X - 3$**

F2 (CALC) log (lcm) X,θ,T x^2 − 1 ,

X,θ,T x^2 + 2 X,θ,T − 3 EXE **$X^3 + 3X^2 - X - 3$**

• rclEqn

Function: Recalls multiple eqn memory contents.

Syntax: rclEqn(memory number [, ..., memory number] [ )]

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Example **To recall the contents of equation memory 2 and equation memory 3**

F3 (EQUA) 2 (rclEqn) 2 , 3 EXE **$3X - Y = 7$**

$3X + 6Y = 63$

- The memory numbers of equations produced as the result of a recall are not updated.

• rclAllEqn (rclAll)

Function: Recall all eqn memory contents.

Syntax: rclAllEqn

- The memory numbers of equations produced as the result of a recall are not updated.

• rewrite (rewrit)

Function: Moves the right side expression to the left side.

Syntax: rewrite({Eq/Ineq/List} [ )]

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Example **To move the right side expression of $X + 3 = 5X - X^2$ to the left side**

F3 (EQUA) 4 (rewrit) X,θ,T + 3 SHIFT • (=)

5 X,θ,T − X,θ,T x^2 EXE **$X^2 - 4X + 3 = 0$**

• exchange (exchng)

Function: Exchanges the right-side and left-side expressions.

Syntax: exchange({Eq/Ineq/List} [ )]

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Example **To exchange the left-side and right-side expressions of $3 > 5X - 2Y$**

F3 (EQUA) 5 (exchng) 3 F3 (EQUA) 1 (INEQUA) 1 (>)
5 ALPHA + (X) − 2 ALPHA − (Y) EXE **$5X - 2Y < 3$**

• eliminate (elim)

Function: Assigns an expression to a variable.

Syntax: eliminate({Eq/Ineq/List} -1, variable, Eq-2 [ )]

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Example **To transform $Y = 2X + 3$ to X= and then substitute into $2X + 3Y = 5$**

F3 (EQUA) 6 (elim) 2 ALPHA + (X) + 3 ALPHA − (Y) SHIFT • (=)
5 , ALPHA + (X) , ALPHA − (Y) SHIFT • (=)
2 ALPHA + (X) + 3 EXE **$4Y - 3 = 5$**

• getRight (getRgt)

Function: Gets the right-side element.

Syntax: getRight({Eq/Ineq/List} [ )]

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Example **To extract the right side element of $Y = 2X^2 + 3X + 5$**

F3 (EQUA) 7 (getRgt) ALPHA − (Y) SHIFT • (=)
2 ALPHA + (X) x^2 + 3 ALPHA + (X) + 5 EXE **$2X^2 + 3X + 5$**

• invert

Function: Inverts two variables.

Syntax: invert({Exp/Eq/Ineq/List} [,variable name 1, variable name 2] [ )]

If you omit the variable names, variables X and Y are inverted.

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Example **To invert X and Y in the expression $2X = Y$**

F3 (EQUA) 8 (invert) 2 X,θ,T SHIFT • (=) ALPHA − (Y) EXE **$2Y = X$**

• absExpand (absExp)

Function: Divides an expression that contains an absolute value into two expressions.

Syntax: absExpand({Eq/Ineq} [ )]

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Example **To strip the absolute value from $| 2X - 3 | = 9$**

F3 (EQUA) 9 (absExp) OPTN F5 (Abs) (2 X,θ,T − 3) SHIFT • (=) 9 EXE

$2X - 3 = 9$ **1**
or $2X - 3 = -9$ **2**

• andConnect (andCon)

Function: Connects two inequalities into a single expression.

Syntax: andConnect(Ineq-1, Ineq-2 [ )]

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Example **To combine $X > -1$ and $X < 3$ into a single inequality**

F3 (EQUA) X,θ,T (andCon) X,θ,T F3 (EQUA) 1 (INEQUA) 1 (>) (−) 1 , X,θ,T F3 (EQUA) 1 (INEQUA) 2 (<) 3 EXE

$-1 < X < 3$

• eqn

Function: Recalls eqn memory contents.

Syntax: eqn(memory number [ )]

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Example **To add 15 to both sides of the equation $6X - 15 = X - 7$, which is stored in equation memory 3**

F4 (eqn) 3) + 1 5 EXE

$6X = X + 8$

• clear (clrVar)

Function: Clears the contents of specific equation (A to Z, r, θ).*[1]

Syntax: clear(variable [ )]
clear({variable list} [ )]

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

F6 (▷) F1 (CLR) 1 (clrVar) ALPHA X,θ,T (A) EXE { }

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Example **To clear the contents of variables X, Y, and Z**

F6 (▷) F1 (CLR) 1 (clrVar) SHIFT × ({) ALPHA + (X) ,
ALPHA − (Y) , ALPHA 0 (Z) SHIFT ÷ (}) EXE { }

• clearVarAll (VarAll)

Function: Clears the contents of all 28 variables (A to Z, r, θ).

Syntax: clearVarAll { }

*[1] When you start out with memories A, B, C, and D, for example, and delete memories A and B, the display shows only C,D because they are the only memories remaining.

■ List Calculation Commands **[OPTN]-[LIST]**

• Dim

Function: Returns the dimension of a list.

Syntax: Dim List

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Example **To determine the dimension of list {1, 2, 3}**

OPTN F1 (LIST) 1 (CALC) 1 (Dim) SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) EXE **3**

• Min

Function: Returns the minimum value of an expression or the elements in a list.

Syntax: Min({List/Exp} [ )]
Min({List/Exp}, {List/Exp} [ )]

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Example **To determine the minimum value of the elements in list {1, 2, 3}**

OPTN F1 (LIST) 1 (CALC) 2 (Min) SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) EXE **1**

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Example **To compare each element of list {1, 2, 3} with the value 2, and produce a list whose elements are the minimum value resulting from each comparison**

OPTN F1 (LIST) 1 (CALC) 2 (Min) SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) , 2 EXE **{1, 2, 2}**

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Example **To compare the elements of list {1, 2, 3} and list {3, 1, 2}, and produce a list whose elements are the minimum value resulting from each comparison**

OPTN F1 (LIST) 1 (CALC) 2 (Min) SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) , SHIFT × ({) 3 , 1 , 2 SHIFT ÷ (}) EXE **{1, 1, 2}**

• Max

Function: Returns the maximum value of an expression or the elements of a list.

Syntax: Max({List/Exp} [ )]
Max({List/Exp}, {List/Exp} [ )]

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Example **To determine the maximum value of the elements in list {1, 2, 3}**

OPTN F1(LIST) 1(CALC) 3(Max) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) EXE **3**

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Example **To compare each element of list {1, 2, 3} with the value 2, and produce a list whose elements are the maximum value resulting from each comparison**

OPTN F1(LIST) 1(CALC) 3(Max) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) , 2 EXE **{2, 2, 3}**

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Example **To compare the elements of list {1, 2, 3} and list {3, 1, 2}, and produce a list whose elements are the maximum value resulting from each comparison**

OPTN F1(LIST) 1(CALC) 3(Max) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) , SHIFT ×({) 3 , 1 , 2 SHIFT ÷(}) EXE **{3, 2, 3}**

• Mean

Function: Returns the mean of the elements in a list.

Syntax: Mean(List [ )]
Mean(List, List [ )]

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the mean of the elements in list {1, 2, 3}**

OPTN F1(LIST) 1(CALC) 4(Mean) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) EXE **2**

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Example **To determine the mean of the elements in list {1, 2, 3} when their frequencies are {3, 2, 1}**

OPTN F1(LIST) 1(CALC) 4(Mean) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) , SHIFT ×({) 3 , 2 , 1 SHIFT ÷(}) EXE $\frac{5}{3}$

• Median

Function: Returns the median of the elements in a list.

Syntax: Median(List [ )]
Median(List, List [ )]

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the median of the elements in list {1, 2, 3}**

OPTN F1(LIST) 1(CALC) 5(Median) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) EXE 2

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Example **To determine the median of the elements in list {1, 2, 3} when their frequencies are {3, 2, 1}**

OPTN F1(LIST) 1(CALC) 5(Median) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) , SHIFT ×({) 3 , 2 , 1 SHIFT ÷(}) EXE $\frac{3}{2}$

• Sum

Function: Returns the sum of the elements in a list.

Syntax: Sum List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the sum of the elements in list {1, 2, 3}**

OPTN F1(LIST) 1(CALC) 6(Sum) SHIFT ×({) 1 , 2 , 3
SHIFT ÷(}) EXE 6

• Prod

Function: Returns the product of the elements in a list.

Syntax: Prod List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the product of the elements in list {2, 3, 4}**

OPTN F1 (LIST) 1 (CALC) 7 (Prod) SHIFT × ({) 2 , 3 , 4
SHIFT ÷ (}) EXE **24**

• Cuml

Function: Returns the cumulative frequency of the elements in a list.

Syntax: Cuml List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the cumulative frequency of the elements in list {1, 2, 3}**

OPTN F1 (LIST) 1 (CALC) 8 (Cuml) SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) EXE **{1, 3, 6}**

• Percent (%)

Function: Returns the percentage of each element in a list, the sum of which is assumed to be 100.

Syntax: Percent List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the percentage of each element in the list {1, 2, 3}**

OPTN F1 (LIST) 1 (CALC) 9 (%) SHIFT × ({) 1 , 2 , 3
SHIFT ÷ (}) EXE

$$\left\{\frac{50}{3},\ \frac{100}{3},\ 50\right\}$$

• ⊿ List

Function: Returns a list whose elements are the differences between the elements of another list.

Syntax: ⊿ List List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To generate a list whose elements are the differences between the elements of list {1, 2, 4}**

OPTN F1 (LIST) 1 (CALC) X,θ,T (⊿List) SHIFT × ({) 1 , 2 , 4
SHIFT ÷ (}) EXE **{1, 2}**

• StdDev

Function: Returns the sample standard deviation of the elements in a list.

Syntax: StdDev List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the sample standard deviation of the elements in list {1, 2, 4}**

OPTN F1 (LIST) 1 (CALC) log (StdDev) SHIFT × ({) 1 , 2 , 4
SHIFT ÷ (}) EXE $\frac{\sqrt{21}}{3}$

• Variance (Vari)

Function: Returns the variance of the elements in a list.

Syntax: Variance List

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To determine the variance of the elements in list {1, 2, 4}**

OPTN F1 (LIST) 1 (CALC) ln (Vari) SHIFT × ({) 1 , 2 , 4
SHIFT ÷ (}) EXE $\frac{7}{3}$

• Seq

Function: Generates a list in accordance with a numeric sequence expression.

Syntax: Seq(Exp, variable, start value, end value, [increment] [ )]

If you do not specify an increment, an increment of 1 is used.

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Example **To generate a list in accordance with the expression: value A, end value 3A, increment A**

OPTN F1 (LIST) 2 (CREATE) 1 (Seq) X,θ,T , X,θ,T , ALPHA X,θ,T (A) , 3
ALPHA X,θ,T (A) , ALPHA X,θ,T (A) EXE **{A, 2A, 3A}**

• Augment (Augmnt)

Function: Returns a new list that appends List 2 to List 1.

Syntax: Augment(List, List [ )]

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Example **To combine list {1, 2} and list {3, 4}**

OPTN F1 (LIST) 2 (CREATE) 2 (Augmnt) SHIFT × ({) 1 , 2
SHIFT ÷ (}) , SHIFT × ({) 3 , 4 SHIFT ÷ (}) EXE **{1, 2, 3, 4}**

• Fill

Function: Replaces the elements of a list with a specified value or expression.
This command can also be used to create a new list whose elements all contain the same value or expression.

Syntax: Fill({Exp/Eq/Ineq}, List [ )]
Fill(Exp, numeric value [ )]

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Example **To replace the elements of list {3, 4} with X**

OPTN F1 (LIST) 2 (CREATE) 3 (Fill) X,θ,T , SHIFT × ({)
3 , 4 SHIFT ÷ (}) EXE **{X, X}**

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Example **To create a list with eight elements, all of which are X**

OPTN F1 (LIST) 2 (CREATE) 3 (Fill) X,θ,T , 8 EXE **{X, X, X, X, X, X, X, X}**

• SortA

Function: Sorts the elements of a list into ascending order.

Syntax: SortA(List [ )]

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To sort the elements of list {1, 5, 3} into ascending order**

OPTN F1 (LIST) 2 (CREATE) 4 (SortA) SHIFT × ({) 1 , 5 , 3
SHIFT ÷ (}) EXE **{1, 3, 5}**

• SortD

Function: Sorts the elements of a list into descending order.

Syntax: SortD(List [ )]

The list must contain values or mathematical expressions only. Equations and inequalities are not allowed.

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Example **To sort the elements of list {1, 5, 3} into descending order**

OPTN F1 (LIST) 2 (CREATE) 5 (SortD) SHIFT × ({) 1 , 5 , 3
SHIFT ÷ (}) EXE **{5, 3, 1}**

• SubList (SubLst)

Function: Extracts a specific section of a list into a new list.

Syntax: SubList(List, start number [, end number] [ )]

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Example **To extract element 2 through element 3 from list {1, 2, 3, 4}**

OPTN F1 (LIST) 2 (CREATE) 6 (SubLst) SHIFT × ({) 1 , 2 , 3
, 4 SHIFT ÷ (}) , 2 , 3 EXE **{2, 3}**

- If you do not specify an end number, all the elements from the start number to the end of the list are extracted.

• List→Mat (L→Mat)

Function: Converts lists into a matrix.

Syntax: List→Mat(List [, ... ,List] [ )]

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Example **To convert list {3, 5} and list {2, 4} into a matrix**

OPTN F1 (LIST) 3 (LIST→) 1 (L→Mat) SHIFT × ({) 3 , 5
SHIFT ÷ (}) , SHIFT × ({) 2 , 4 SHIFT ÷ (}) EXE

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

• List→Vect (L→Vect)

Function: Converts a list into a vector.

Syntax: List→Vect List

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Example **To convert list {3, 2} into a vector**

OPTN F1 (LIST) 3 (LIST→) 2 (L→Vect) SHIFT × ({) 3 , 2
SHIFT ÷ (}) EXE

[3, 2]

■ Matrix Calculation Commands **[OPTN]-[MAT]**

• Dim

Function: Returns the dimensions of a matrix.

Syntax: Dim Mat

• • • • •

Example **To determine the dimensions of the matrix below**

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

OPTN F2 (MAT) 1 (CALC) 1 (Dim) SHIFT + ([ ) SHIFT + ([ )
1 , 2 , 3 SHIFT − ( ]) SHIFT + ([ ) 4 , 5 , 6
SHIFT − ( ]) SHIFT − ( ]) EXE **{2, 3}**

• Det

Function: Returns the determinant of a matrix.

Syntax: Det Mat

• • • • •

Example **To determine the determinant of the matrix below**

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

OPTN F2 (MAT) 1 (CALC) 2 (Det) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 4 , 5
SHIFT − ( ]) SHIFT − ( ]) EXE **– 3**

• Norm

Function: Returns the norm of a matrix.

Syntax: Norm Mat

• • • • •

Example **To determine the norm of the matrix below**

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

OPTN F2 (MAT) 1 (CALC) 3 (Norm) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 4 , 5
SHIFT − ( ]) SHIFT − ( ]) EXE **$\sqrt{46}$**

• EigVc

Function: Returns the eigenvector of a matrix.

Syntax: EigVc Mat

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Example **To determine the eigenvector of the matrix below**

$$\begin{bmatrix}3 & 4\\1 & 3\end{bmatrix}$$

OPTN F2(MAT) 1(CALC) 4(EigVc)
SHIFT +([ ) SHIFT +([ ) 3 , 4
SHIFT −( ]) SHIFT +([ ) **[0.894427191 – 0.894427191]**
1 , 3 SHIFT −( ]) SHIFT −( ]) EXE **[0.4472135955 0.4472135955]**

Eigenvectors are stacked vertically on the display.

In this example, (0.894427191 0.4472135955) are the eigenvectors that correspond to 5, while (–0.894427191 0.4472135955) are the eigenvectors that correspond to 1.

An eigenvector has an infinite number of solutions. The eigenvector displayed by this command is the one with a size of 1.

• EigVl

Function: Returns the eigenvalue of a matrix.

Syntax: EigVl Mat

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Example **To determine the eigenvalue of the matrix below**

$$\begin{bmatrix}3 & 4\\1 & 3\end{bmatrix}$$

OPTN F2(MAT) 1(CALC) 5(EigVl) SHIFT +([ ) SHIFT +([ )
3 , 4 SHIFT −( ]) SHIFT +([ ) 1 , 3
SHIFT −( ]) SHIFT −( ]) EXE **{5, 1}**

• Rref

Function: Returns the reduced row echelon form of a matrix.

Syntax: Rref Mat

• • • • •

Example **To determine the reduced row echelon form of the matrix below**

$$\begin{bmatrix} -2 & -2 & 0 & -6 \\ 1 & -1 & 9 & -9 \\ -5 & 2 & 4 & -4 \end{bmatrix}$$

OPTN F2 (MAT) 1 (CALC) 6 (Rref) SHIFT + ([ ) SHIFT + ([ )
(–) 2 , (–) 2 , 0 , (–) 6 SHIFT – ( ]) SHIFT + ([ )
1 , (–) 1 , 9 , (–) 9 SHIFT – ( ])
SHIFT + ([ ) (–) 5 , 2 , 4 , (–) 4
SHIFT – ( ]) SHIFT – ( ]) EXE

$$\begin{bmatrix} 1 & 0 & 0 & \frac{66}{71} \\ 0 & 1 & 0 & \frac{147}{71} \\ 0 & 0 & 1 & -\frac{62}{71} \end{bmatrix}$$

• Ref

Function: Returns the row echelon form of a matrix.

Syntax: Ref Mat

• • • • •

Example **To determine the row echelon form of the matrix below**

$$\begin{bmatrix} -2 & -2 & 0 & -6 \\ 1 & -1 & 9 & -9 \\ -5 & 2 & 4 & -4 \end{bmatrix}$$

OPTN F2 (MAT) 1 (CALC) 7 (Ref) SHIFT + ([ ) SHIFT + ([ )
(–) 2 , (–) 2 , 0 , (–) 6 SHIFT – ( ]) SHIFT + ([ )
1 , (–) 1 , 9 , (–) 9 SHIFT – ( ])
SHIFT + ([ ) (–) 5 , 2 , 4 , (–) 4
SHIFT – ( ]) SHIFT – ( ]) EXE

$$\begin{bmatrix} 1 & 1 & 0 & 3 \\ 0 & 1 & -\frac{9}{2} & 6 \\ 0 & 0 & 1 & -\frac{62}{71} \end{bmatrix}$$

• LU

Function: Returns the LU resolution of a matrix.

Syntax: LU(Mat, lower memory, upper memory)

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Example **To determine the LU resolution of the matrix below**

$$\begin{bmatrix} 6 & 12 & 18 \\ 5 & 14 & 31 \\ 3 & 8 & 18 \end{bmatrix}$$

The lower matrix is assigned to variable A, while the upper matrix is assigned to variable B.

OPTN F2 (MAT) 1 (CALC) 8 (LU) SHIFT + ([ ) SHIFT + ([ )
6 , 1 2 , 1 8 SHIFT − ( ]) SHIFT + ([ )
5 , 1 4 , 3 1 SHIFT − ( ]) SHIFT + ([ )
3 , 8 , 1 8 SHIFT − ( ]) SHIFT − ( ]) ,
ALPHA X,θ,T (A) , ALPHA log (B) EXE

$$\begin{bmatrix} 6 & 12 & 18 \\ 0 & 4 & 16 \\ 0 & 0 & 1 \end{bmatrix}$$

The upper matrix is displayed as the calculation result.

To display the lower matrix, recall the lower matrix variable (A in this example) specified by the command.

ALPHA X,θ,T (A) EXE

$$\begin{bmatrix} 1 & 0 & 0 \\ \frac{5}{6} & 1 & 0 \\ \frac{1}{2} & \frac{1}{2} & 1 \end{bmatrix}$$

To display the upper matrix, recall the upper matrix variable (B in this example) specified by the command.

• Trn

Function: Transposes a matrix.

Syntax: Trn Mat

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Example **To transpose the matrix below**

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

OPTN F2 (MAT) 2 (CREATE) 1 (Trn) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 3 , 4
SHIFT − ( ]) SHIFT − ( ]) EXE

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

• Augment (Augmnt)

Function: Combines two matrices.

Syntax: Augment(Mat, Mat [ )]

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Example **To combine the two matrices below**

$$\begin{bmatrix} 1 & 2 \\ 3 & 4 \end{bmatrix} \begin{bmatrix} 5 & 6 \\ 7 & 8 \end{bmatrix}$$

OPTN F2 (MAT) 2 (CREATE) 2 (Augmnt) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 3 , 4
SHIFT − ( ]) SHIFT − ( ]) , SHIFT + ([ ) SHIFT + ([ )
5 , 6 SHIFT − ( ]) SHIFT + ([ ) 7 , 8
SHIFT − ( ]) SHIFT − ( ]) EXE

$$\begin{bmatrix} 1 & 2 & 5 & 6 \\ 3 & 4 & 7 & 8 \end{bmatrix}$$

• Identify (Ident)

Function: Creates an identity matrix

Syntax: Ident numeric value

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Example **To create a 2 × 2 identity matrix**

OPTN F2 (MAT) 2 (CREATE) 3 (Ident) 2 EXE

$$\begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

• Fill

Function: Replaces the elements of a matrix with a specified value or expression.

This command can also be used to create a new matrix whose elements all contain the same value or expression.

Syntax: Fill(Exp, Mat [ )]

Fill(Exp, number of lines, number of rows [ )]

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Example **To replace the elements of the matrix below with X**

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

OPTN F2 (MAT) 2 (CREATE) 4 (Fill) X,θ,T , SHIFT + ([ )
SHIFT + ([ ) 3 , 4 SHIFT − ( ]) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT − ( ]) EXE

$$\begin{bmatrix} X & X \\ X & X \end{bmatrix}$$

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Example **To create a 2 × 3 matrix, all of whose entries are X**

OPTN F2 (MAT) 2 (CREATE) 4 (Fill) X,θ,T , 2 , 3 EXE

$$\begin{bmatrix} X & X & X \\ X & X & X \end{bmatrix}$$

• SubMat

Function: Extracts a specific section of a matrix into a new matrix.

Syntax: SubMat(Mat [, start row] [, start column] [, end row] [, end column] [ )]

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Example **To extract the section from row 2, column 2 to row 3, column 3 from the following matrix**

$$\begin{bmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{bmatrix}$$

OPTN F2 (MAT) 2 (CREATE) 5 (SubMat) SHIFT + ([ ) SHIFT + ([ )
1 , 2 , 3 SHIFT − ( ]) SHIFT + ([ ) 4 , 5 , 6
SHIFT − ( ]) SHIFT + ([ ) 7 , 8 , 9 SHIFT − ( ])
SHIFT − ( ]) , 2 , 2 , 3 , 3 EXE

$$\begin{bmatrix} 5 & 6 \\ 8 & 9 \end{bmatrix}$$

- If you do not specify an end row and column, all the entries from the start row/column to the end of the matrix are extracted.

• Diag

Function: Extracts the diagonal elements of a matrix.

Syntax: Diag Mat

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Example **To extract the diagonal elements of the matrix below**

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

OPTN F2 (MAT) 2 (CREATE) 6 (Diag) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 3 , 4
SHIFT − ( ]) SHIFT − ( ]) EXE **[1, 4]**

• Mat→List (M→List)

Function: Converts a specific column of a matrix into a list.

Syntax: Mat→List(Mat, column number [ )]

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Example **To convert column 2 of the matrix below to a list**

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

OPTN F2 (MAT) 3 (MAT→) 1 (M→List) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 3 , 4
SHIFT − ( ]) SHIFT − ( ]) , 2 EXE **{2, 4}**

• Mat→Vect (M→Vect)

Function: Converts a specific column of a matrix into a vector.

Syntax: Mat→Vect(Mat, column number [ )]

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Example **To convert column 2 of the matrix below to a vector**

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

OPTN F2 (MAT) 3 (MAT→) 2 (M→Vect) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 3 , 4
SHIFT − ( ]) SHIFT − ( ]) , 2 EXE **[2, 4]**

• Swap

Function: Swaps two rows of a matrix.

Syntax: Swap Mat, row number 1, row number 2

• • • • •

Example **To swap row 1 with row 2 of the following matrix**

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

OPTN F2 (MAT) 4 (ROW) 1 (Swap) SHIFT + ([ ) SHIFT + ([ )
1 , 2 SHIFT − ( ]) SHIFT + ([ ) 3 , 4
SHIFT − ( ]) SHIFT − ( ]) , 1 , 2 EXE

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

• ∗Row

Function: Returns the scalar product of a row of a matrix.

Syntax: ∗Row(Exp, Mat, row number [ )]

• • • • •

Example **To multiply row 1 of the matrix below by X**

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

OPTN F2 (MAT) 4 (ROW) 2 (∗Row) X,θ,T , SHIFT + ([ )
SHIFT + ([ ) 1 , 2 SHIFT − ( ]) SHIFT + ([ )
3 , 4 SHIFT − ( ]) SHIFT − ( ]) , 1 EXE

$$\begin{bmatrix} X & 2X \\ 3 & 4 \end{bmatrix}$$

• ∗Row+

Function: Calculates the scalar product of one row of a matrix and adds the result to another row.

Syntax: ∗Row+(Exp, Mat, line number 1, line number 2 [ )]

• • • • •

Example **To multiply row 1 of the matrix below by X, and add the result to row 2**

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

OPTN F2 (MAT) 4 (ROW) 3 (∗Row+) X,θ,T , SHIFT + ([ )
SHIFT + ([ ) 1 , 2 SHIFT − ( ]) SHIFT + ([ )
3 , 4 SHIFT − ( ]) SHIFT − ( ]) , 1 , 2 EXE

$$\begin{bmatrix} 1 & 2 \\ X+3 & 2X+4 \end{bmatrix}$$

• Row+

Function: Adds one row of a matrix and to another row.

Syntax: Row+(Mat, row number 1, row number 2 [ )]

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Example **To add row 1 of the matrix below to row 2**

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

OPTN F2(MAT) 4(ROW) 4(Row+) SHIFT +([ )
SHIFT +([ ) 1 , 2 SHIFT −( ]) SHIFT +([ )
3 , 4 SHIFT −( ]) SHIFT −( ]) , 1 , 2 EXE

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

■ Vector Calculation Commands **[OPTN]-[VECT]**

• Dim

Function: Returns the dimension of a vector.

Syntax: Dim Vect

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Example **To determine the dimension of the vector (1 2 3)**

OPTN F3 (VECT) 1 (CALC) 1 (Dim) SHIFT + ([ ) 1 , 2 , 3
SHIFT − ( ]) EXE **3**

• CrossP

Function: Returns the cross product of two vectors.

Syntax: CrossP(Vect, Vect [ )]

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Example **To determine the cross product of vector (1 2 3) and vector (4 5 6)**

OPTN F3 (VECT) 1 (CALC) 2 (CrossP) SHIFT + ([ ) 1 , 2 , 3
SHIFT − ( ]) , SHIFT + ([ ) 4 , 5 , 6 SHIFT − ( ]) EXE **[– 3, 6, – 3]**

• DotP

Function: Returns the dot product of two vectors.

Syntax: DotP(Vect, Vect [ )]

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Example **To determine the dot product of vector (1 2 3) and vector (4 5 6)**

OPTN F3 (VECT) 1 (CALC) 3 (DotP) SHIFT + ([ ) 1 , 2 , 3
SHIFT − ( ]) , SHIFT + ([ ) 4 , 5 , 6 SHIFT − ( ]) EXE **32**

• Norm

Function: Returns the norm of a vector.

Syntax: Norm Vect

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Example **To determine the norm of the vector (1 2 3)**

OPTN F3 (VECT) 1 (CALC) 4 (Norm) SHIFT + ([ ) 1 , 2 , 3
SHIFT − ( ]) EXE **$\sqrt{14}$**

• UnitV

Function: Normalizes a vector.

Syntax: UnitV Vect

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Example **To normalize a vector (1 2 3)**

OPTN F3 (VECT) 1 (CALC) 5 (UnitV)
SHIFT + ([ ) 1 , 2 , 3
SHIFT − ( ]) EXE

$$\left[\frac{\sqrt{14}}{14}, \frac{\sqrt{14}}{7}, \frac{3\sqrt{14}}{14}\right]$$

• Angle

Function: Returns the angle formed by two vectors.

Syntax: Angle(Vect, Vect [ )]

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Example **To determine the angle formed by vector (1 2) and vector (3 4) (Unit Angle: Rad)**

OPTN F3 (VECT) 1 (CALC) 6 (Angle) SHIFT + ([ ) 1 , 2
SHIFT − ( ]) , SHIFT + ([ ) 3 , 4 SHIFT − ( ]) EXE

$$\cos^{-1}\left(\frac{11\sqrt{5}}{25}\right)$$

• Augment (Augmnt)

Function: Combines two vectors.

Syntax: Angle(Vect, Vect [ )]

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Example **To combine vector (1 2) and vector (3 4)**

OPTN F3 (VECT) 2 (CREATE) 1 (Augmnt) SHIFT + ([ ) 1 , 2
SHIFT − ( ]) , SHIFT + ([ ) 3 , 4 SHIFT − ( ]) EXE

[1, 2, 3, 4]

• Fill

Function: Replaces the elements of a vector with a specified value or expression.

Syntax: Fill(Exp, Vect [ )]

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Example **To replace the components of the vector below with X**

OPTN F3 (VECT) 2 (CREATE) 2 (Fill) X,θ,T , SHIFT + ([ )
3 , 4 SHIFT − ( ]) EXE

[X, X]

• Vect→List (V→List)

Function: Converts a vector into a list.

Syntax: Vect→List Vect

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Example **To convert vector (3 2) into a list**

OPTN F3 (VECT) 3 (VECT→) 1 (V→List) SHIFT + ([ ) 3 , 2
SHIFT − ( ]) EXE **{3, 2}**

• Vect→Mat (V→Mat)

Function: Converts vectors into a matrix.

Syntax: Vect→Mat(Vect [, ... ,Vect] ( ])

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Example **To convert vector (3 5) and (2 4) into a matrix**

OPTN F3 (VECT) 3 (VECT→) 2 (V→Mat) SHIFT + ([ ) 3 , 5
SHIFT − ( ]) , SHIFT + ([ ) 2 , 4 SHIFT − ( ]) EXE

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

7-2 Algebra Mode

The CAS Mode automatically provides you with the final result only. The Algebra Mode, on the other hand, lets you obtain intermediate results at a number of steps along the way.

On the Main Menu, select the **ALGEBRA** icon to enter the Algebra Mode. The screens in this mode are the same as those in the CAS Mode.

Operations in the Algebra Mode are identical to those in the CAS Mode, except for a number of limitations. Also, the following commands are available in the Algebra Mode only.

• arrange (arrang)

Function: Collects like terms and arranges them in order, starting with the term that contains the smallest coefficient.

Syntax: arrange({Exp/Eq/Ineq} [ )]

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Example **To arrange 2X + 3 – 5X + 8Y in sequence of its variables**

F1(TRNS) 9(arrang) 2 ALPHA +(X) + 3 −
5 ALPHA +(X) + 8 ALPHA −(Y) EXE **– 5X + 2X + 8Y + 3**

• replace (replac)

Function: Replaces a variable with the expression assigned to the corresponding expression variable.

Syntax: replace({Exp/Eq/Ineq} [ )]

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Example **To replace S in the expression 3X + 2S, when the expression 2X + 1 is assigned to S**

F1(TRNS) X,θ,T(replac) 3 X,θ,T + 2 ALPHA ×(S) EXE **3X + 2 (2X + 1)**

7-3 Tutorial Mode

On the Main Menu, select the **TUTOR** icon to enter the Tutorial Mode.

Tutorial Mode Flow

1. Specify the expression type.
2. Define the expression.
3. Specify the solve mode.

Specifying the Expression Type

Entering the Tutorial Mode displays a menu of the following expression types.

- Linear Equation
- Linear Inequality
- Quadratic Equation
- Simul (Simultaneous) Equation

Use the cursor keys to highlight the expression type you want to specify, and then press EXE.

This displays a list of formulas for the expression type you select. Move the cursor to the formula you want to use.

In the case of Linear Inequality, press F4(TYPE) to select the inequality type.

The following shows the formulas available for each type of expression.

Linear Equation — 6 Types

- $AX = B$
- $AX + B = C$
- $A(BX + C) = D(EX + F)$
- $X + A = B$
- $AX + B = CX + D$
- $|AX + B| = C$

Linear Inequality — 6 × 4 Types

- $AX \{ > < \geqq \leqq \} B$
- $AX + B \{ > < \geqq \leqq \} C$
- $A(BX + C) \{ > < \geqq \leqq \} D(EX + F)$
- $X + A \{ > < \geqq \leqq \} B$
- $AX + B \{ > < \geqq \leqq \} CX + D$
- $|AX + B| \{ > < \geqq \leqq \} C$

Quadratic Equation — 5 Types

- $AX^2 = B$
- $AX^2 + BX + C = 0$
- $AX^2 + BX + C = DX^2 + EX + F$
- $(AX + B)^2 = C$
- $AX^2 + BX + C = D$

Simul Equation — 10 Types

- $AX + BY = C$
  $DX + EY = F$
- $AX + BY + C = 0$
  $DX + EY + F = 0$
- $AX + BY = C$
  $Y = DX + E$
- $AX + BY = C$
  $DX + EY + F = GX + HY + I$
- $AX + BY + C = DX + EY + F$
  $Y = GX + H$
- $Y = AX + B$
  $Y = CX + D$
- $AX + BY + C = DX + EY + F$
  $GX + HY + I = JX + KY + L$
- $AX + BY = C$
  $DX + EY + F = 0$
- $AX + BY + C = 0$
  $Y = DX + E$
- $AX + BY + C = 0$
  $DX + EY + F = GX + HY + I$

Pressing F6(EXCH) reverses the left side and right side elements of the expression.

■ Defining the Expression

In this step, you specify coefficients and define the expression. You can select any of the three following methods for specifying coefficients.

- {**RAND**} ... {random generation of coefficients}
- {**INPUT**} ... {key input of coefficients}
- {**SMPL**} ... {selection of coefficients from samples}
- {**SEED**} ... {selection of a number from 1 to 99 (specification of the same number displays the same expression)}

F1(RAND) or EXE generates random coefficients and defines the expression.

F2(INPUT) displays the coefficient input screen. Input coefficients, pressing EXE after each. After you finish inputting all the coefficients, press F6(EXE) to define the coefficient.

F3(SMPL) displays a number of preset sample expressions. Highlight the one you want to use and then press EXE to define it.

Pressing F4(SEED) displays a number selection screen. When you want to create the same problem on another calculator, specify an appropriate matching number and press EXE.

No matter what method you use, the expression you define is displayed in the output area.

You can copy an expression to the Graph Mode as a graph function*[1].

- {**L•COP**}/{**R•COP**} ... copy {left side element}/{right side element} as a graph function

(Simultaneous Equation Mode*[2])

- {**1•COP**}/{**2•COP**} ... copy {first}/{second} expression as a graph function

---

*[1] In the case of an inequality, the inequality symbols are also copied.

*[2] Simultaneous equations are transformed to the format Y = AX + B when copied.

■ Specifying the Solve Mode

You can select one of the following three solve modes for the displayed expression.

- {**VRFY**} ... {Verify Mode}

  In this mode, you input a solution for verification of whether or not it is correct. It provides a good way to check solutions you arrive at manually.

- {**MANU**} ... {Manual Mode}

  In this mode, you manually input algebra commands, transform the expression, and calculate a result.

- {**AUTO**} ... {Auto Mode}

  In this mode, the solution is produced automatically, one step at a time.

■ Verify Mode

Press F4 (VRFY) to enter the Verify Mode.

The expression is shown in the top line of the display. Input the solution underneath it, and then press F6 (JUDG) to determine whether the solution is correct.

The verification result screen shows the left side and right side verification result (except for a linear equation).

- However, in the case where a linear equation or quadratic equation has two solutions, the left side and right side are obtained for the value where the pointer is located.
- In the case of simultaneous equations where the left side and right side of the second equation are dissimilar even though the left side and right side of the first equation match, the left side and right side of the second equation only are obtained. In other cases, the left side and right side of the first equation are obtained.

The type of solution input screen that appears is selected according to the expression type. To input a different type, press F1 (TYPE) and then select the solution type you want to want to use. Available solution types depend on the mode.

- {**X = a**} ... X has one solution (X = a) (linear equation default)
- {**X = a, b**} ... X has two solutions (X = a, X = b) (quadratic equation default)
- {**X = a, Y=**} ... X and Y have one solution each (X = a, Y = b) (simultaneous equation default)
- {**X > a**} ... X { > < ≧≦ } a (linear inequality default)
- {**X < a, b <**} ... X < a, b < X or X ≦ a, b ≦ X
- {**a < X < b**} ... a < X< b, a ≦ X ≦ b or X = a
- {**Identi**} **(Identity)** ... identity of left side and right side
- {**Many**} **(Many Solutions)** ... many solutions
- {**No sol**} **(No Solution)** ... no solution

You can press F4(MANU) to change to the Manual Mode or F5(AUTO) to change to the Auto Mode.

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Example **To solve 4X = 8 in the Verify Mode**

(Linear Equation)(AX = B)

F2(INPUT) 4 EXE 8 EXE F6(EXE)

4X=8
X=2

F4(VRFY) 2 EXE

F6(JUDG)

4X=8
X=

TRUE
Press:[ESC]

Manual Mode

Press F5(MANU) to enter the Manual Mode.

As with the Algebra Mode, the screen is divided between an input area and a display area. This means you can select Algebra Mode commands from the function menu, transform the expression, and solve it.

Operation is the same as that in the Algebra Mode.

After you obtain a result, you can press F5(JUDG) to determine whether or not it is correct.

- {**DISP**} ... Determines whether the expression in the display area is a correct solution.
- {**Identi**} ... identity of left side and right side
- {**Many**} ... many solutions
- {**No sol**} ... no solution

You can press F6(AUTO) to change to the Auto Mode.

● ● ● ● ●

Example **Solve 4X = 8 in the Manual Mode**

(Linear Equation)(AX=B)

F2(INPUT) 4 EXE 8 EXE F6(EXE)

F5(MANU)

```
rclEqn(1)
4X=8
```

F4(eqn) 1) ÷ 4

EXE

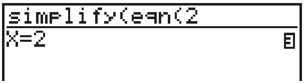
eqn(1)/4

$\frac{4X}{4}=\frac{8}{4}$

F1(TRNS) 1(smplfy)

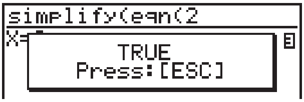
F4(eqn) 2

EXE



```
simplify(eqn(2
X=2
```

F5(JUDG) 1(DISP)



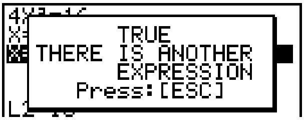
```
simplify(eqn(2
     TRUE
  Press:[ESC]
```

● ● ● ● ●

Example **$4X^2 = 16$**

True (X = 2, X = – 2)

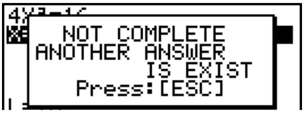
Besides “TRUE” the messages shown below can also appear as the result of verification. “CAN NOT JUDGE” appears in the Manual Mode, while the other messages appear in both the Verify Mode and Manual Mode.



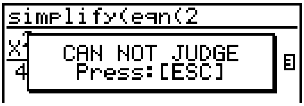
TRUE
THERE IS ANOTHER
EXPRESSION
Press:[ESC]

4X²=16

FALSE
Press:[ESC]



NOT COMPLETE
ANOTHER ANSWER
IS EXIST
Press:[ESC]



simplify(eqn(2

CAN NOT JUDGE
Press:[ESC]

Auto Mode

Press F6(AUTO) to enter the Auto Mode.

In the Simultaneous Equation Mode, you must also select SBSTIT (Substitution Method) or ADD-SU (Addition/Subtraction Method).

The Substitution Method first transforms the equation to the format Y = aX + b, and substitutes aX + b for Y[1] in the other equation.

The Addition/Subtraction Method multiplies both sides of the expression by the same value to isolate the coefficient X (or Y).

As with the Algebra Mode, the screen is divided between an input area and a display area.

Each press of F6(NEXT) advances to the next step. F6(NEXT) is not shown on the display when the solution is obtained.

You can scroll back through the steps by pressing F1(BACK).

● ● ● ● ●

Example **To solve 4X = 8 in the Auto Mode**

(Linear Equation)(AX = B)

F2(INPUT) 4 EXE 8 EXE F6(EXE)

F6(AUTO)

rclEqn(1)

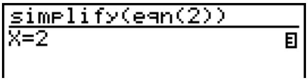
4X=8

F6(NEXT)

eqn(1)/4

$\frac{4X}{4}=\frac{8}{4}$

F6(NEXT)



simplify(eqn(2))

X=2

---

[1] You can press F5(ADD SU) at any time to switch from Substitution Method to Addition / Subtraction Method.

See 7-1-8 for information about graph functions.

7-4 Algebra System Precautions

- If an algebraic operation cannot be performed for some reason, the original expression remains on the display.
- It may take considerable time to perform an algebraic operation. Failure of a result to appear immediately does not indicate malfunction of the computer.
- Any expression can be displayed in various different formats. Because of this, you should not assume that an expression is wrong just because it does not appear as you expected.
- This calculator performs integration calculations under the assumption that integrals are always positive, even when the integrals switch between positive and negative.

$f(x)$
$F(x)$: primitive function of $f(x)$

$$\int_a^b f(x)dx = F(b) - F(a)$$

Chapter 8

Programming

This unit comes with approximately 144 kbytes of memory.

- You can check how much memory has been used and how much remains by entering the SYSTEM Mode from the Main Menu, and then pressing F1(Mem). See “9-2 Memory Operations” for details.

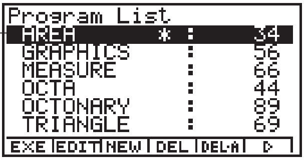
8-1 Basic Programming Steps

Description

Commands and calculations are executed sequentially, just like manual calculation multistatements.

Set Up

1. From the Main Menu, enter the PRGM Mode. When you do, a program list appears on the display.



```
Program List
 AREA        * :    34
 GRAPHICS      :    56
 MEASURE       :    66
 OCTA          :    44
 OCTONARY      :    89
 TRIANGLE      :    69
EXE EDIT NEW DEL DEL·A ▷
```

Selected program area
(use ▲ and ▼ to move)

Files are listed in the alphabetic sequence of their names.

Execution

2. Register a file name.
3. Input the program.
4. Run the program.

If there are no programs stored in memory when you enter the PRGM Mode, the message "**No Programs**" appears on the display and only the NEW item (F3) is shown in the function menu.

The values to the right of the program list indicate the number of bytes used by each program.

A file name can be up to eight characters long.

The following are the characters you can use in a file name:
A through Z, r, θ, spaces, [,], {, }, ', ", ~,
0 through 9, ., +, −, ×, ÷

Registering a file name uses 24 bytes of memory.

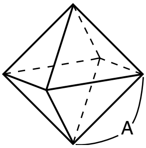
The file name input screen remains on the display if you press EXE without inputting a file name.

To exit the file name input screen and return to the program list without registering a file name, press ESC.

● ● ● ● ●

Example 1 **To calculate the surface area (cm²) and volume (cm³) of three regular octahedrons when the length of one side is 7, 10, and 15 cm, respectively.**

Store the calculation formula under the file name OCTA.



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 A is known.

$$S = 2\sqrt{3}\,A^2, \quad V = \frac{\sqrt{2}}{3}\,A^3$$

Procedure

① MENU PRGM

② F3 (NEW) O C T A EXE *1

③ SHIFT VARS (PRGM) F3 (?) → ALPHA X,θ,T (A) F6 (▷) F6 (▷) F3 (:)*2
2 × SHIFT x² (√) 3 × ALPHA X,θ,T (A) x² F6 (▷) F4 (◢)
SHIFT x² (√) 2 ÷ 3 × ALPHA X,θ,T (A) ^ 3
ESC ESC

④ F1 (EXE) or EXE
7 EXE (Value of A)
EXE


S when A = 7
V when A = 7

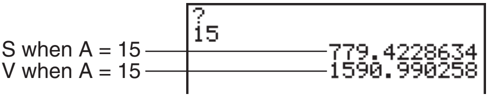
```
?
7
          169.7409791
          161.6917506
```

EXE
EXE 1 0 EXE
EXE


S when A = 10
V when A = 10

```
?
10
          346.4101615
          471.4045208
```

EXE
EXE 1 5 EXE
EXE *3


S when A = 15
V when A = 15

```
?
15
          779.4228634
          1590.990258
```

*1 Press F3 (NEW) and the cursor changes form to indicate alpha character input.

*2 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 x² (√) 3 × <value of A> x² EXE

Volume V .... SHIFT x² (√) 2 ÷ 3 × <value of A> ^ 3 EXE

*3 Pressing EXE while the final result of a program is on the display changes to the program list.

You can also run a program while in the **RUN• MAT Mode** by inputting: Prog "<file name>" EXE.

Pressing EXE while the final result of a program executed using this method is on the display re-executes the program.

An error occurs if the program specified by Prog "<file name>" cannot be found.

8-2 Program Mode Function Keys

- {**NEW**} ... {new program}

• When you are registering a file name

- {**RUN**}/{**BASE**} ... {general calculation}/{number base} program input
- {**🔑**} ... {password registration}
- {**SYBL**} ... {symbol menu}

• When you are inputting a program —— F1 (RUN) … default

- {**JUMP**} ... {top}/{bottom} of program
- {**SRC**} ... {search}
- {**MAT**}/ {**STAT**}/{**LIST**}/{**GRPH**}/{**DYNA**}/{**RECR**}
  ... {matrix}/{statistic}/{list}/{graph}/ {Dynamic Graph}/{recursion} menu

- Pressing SHIFT VARS (PRGM) displays the following PRGM (PROGRAM) menu.
  - {**Prog**} ... {program recall}
  - {**JUMP**} ... {jump command menu}
  - {**?**}/{**◢**} ... {input}/{output} command
  - {**I/O**} ... {I/O control/transfer command menu}
  - {**IF**}/{**FOR**}/{**WHLE**}/{**CTRL**}/{**LOGIC**}
    ... {conditional jump}/{loop control}/{conditional loop control}/{program control}/{logical operation} command menu
  - {**CLR**}/{**DISP**} ... {clear}/{display} command menu
  - {**:**} .... {separator for expressions and commands}

See “8-5 Command Reference” for full details on each of these commands.

- Pressing CTRL F3 (SET UP) displays the mode command menu shown below.
  - {**ANGL**}/{**DISP**}/{**CPLX**}/{**GRPH**}/{**STAT**}/{**DERIV**}/{**T-VAR**}/{**Σ DSP**}

See “SET UP Screen Function Key Menus” on page 1-7-1 for details about each of these commands.

• When you are inputting a program —— F2(BASE)[*1]

- {**JUMP**}/{**SRC**}
- {**d~o**} ... {decimal}/{hexadecimal}/{binary}/{octal} value input
- {**LOG**} ... {logical operators}
- {**DISP**} ... conversion of displayed value to {decimal}/{hexadecimal}/{binary}/{octal}
- {**SYBL**} ... {symbol menu}

- Pressing SHIFT VARS (PRGM) displays the following PRGM (PROGRAM) menu.

  - {**Prog**}/{**JUMP**}/{**?**}/{**◢**}
  - {**= ≠ <**} ... {logical operator menu}
  - {**:**} .... {separator for expressions and commands}

- Pressing CTRL F3 (SET UP) displays the mode command menu shown below.

  - {**Dec**}/{**Hex**}/{**Bin**}/{**Oct**}

- {**EXE**}/{**EDIT**}
  ... program {execute}/{edit}
- {**NEW**} ... {new program}
- {**DEL**}/{**DEL·A**}
  ... {specific program}/{all program} delete
- {**SRC**}/{**REN**}
  ... file name {search}/{change}

[*1] Programs input after pressing F2 (BASE) are indicated by **B** to the right of the file name.

8-3 Editing Program Contents

■ 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 that require debugging.

- 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
  Press:[ESC]
```

When such a message appears, press ESC to display the place in the program where the error was caused. The cursor will be flashing at the location of the problem. Check the “Error Message Table” (page α-1-1) for steps you should take to correct the situation.

- Note that pressing ESC does not display the location of the error if the program is password protected. Instead, it returns to the program list screen.

• To eliminate bugs that cause bad results

If your program produces results that are not what you normally expect, check the contents of the program and make necessary changes.
The F1(JUMP) key is also useful when editing program contents.

F1(JUMP) 1(Top) .... Moves the cursor to the top of the program

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

F1(JUMP) 2(Bottom)... Moves the cursor to the bottom of the program

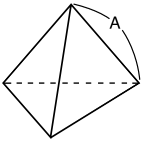
```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

Using an Existing Program to Create a New Program

Sometimes you can input a new program by using a program already in memory as a base. Simply recall the existing program, make the changes you need, and then execute it.

● ● ● ● ●

Example 2 To use the OCTA program (page 8-1-2) to create a program that calculates the surface area (cm²) and volume (cm³) of regular tetrahedrons when the length of one side is 7, 10, and 15 cm
Use TETRA as the file name.



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 A 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 VARS (PRGM) F3 (?) → ALPHA X,θ,T (A) F6 (▷) F6 (▷) F3 (:)
Surface Area S .... SHIFT x^2 (√‾) 3 × ALPHA X,θ,T (A) x^2 F6 (▷) F4 (◢)
Volume V .... SHIFT x^2 (√‾) 2 ÷ $\underline{\text{1 2}}$ × ALPHA X,θ,T (A) ^ 3

Compare this with the program for calculating the surface area and volume of a regular octahedron.

Length of One Side A .. SHIFT VARS (PRGM) F3 (?) → ALPHA X,θ,T (A) F6 (▷) F6 (▷) F3 (:)
Surface Area S .... $\underline{\text{2 ×}}$ SHIFT x^2 (√‾) 3 × ALPHA X,θ,T (A) x^2 F6 (▷) F4 (◢)
Volume V .... SHIFT x^2 (√‾) 2 ÷ $\underline{\text{3}}$ × ALPHA X,θ,T (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)

Now edit OCTA to produce the TETRA program.

1. Edit the program name.

   F6 (▷) F2 (REN) AC T E T R A EXE

```
Program List
 TETRA        :    441
 TRIANGLE     :     69
```

2. Edit the program contents.

   F2 (EDIT)

```
======TETRA   ======
?→A:2×√3×A²◢
√2/3×A^3
```

   ▶ ▶ ▶ ▶ DEL DEL

   ▼ ◀ DEL 1 2

```
======TETRA   ======
?→A:√3×A²◢
√2/12×A^3
```

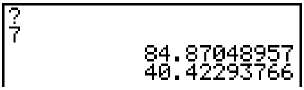
   ESC

3. Try running the program.

   F1 (EXE) or EXE

   7 EXE (Value of A)

   EXE

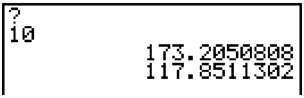


```
?
7
                 84.87048957
                 40.42293766
```

   EXE

   EXE 1 0 EXE

   EXE

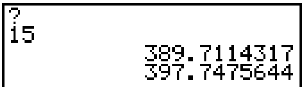


```
?
10
                 173.2050808
                 117.8511302
```

   EXE

   EXE 1 5 EXE

   EXE



```
?
15
                 389.7114317
                 397.7475644
```

Searching for Data Inside a Program

• • • • •

Example To search for the letter "A" inside the program named OCTA

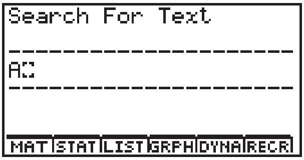
1. Recall the program.

2. Press F2(SRC) or EXE and input the data you want to find.

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

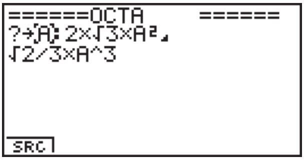
F2(SRC)

ALPHA X,θ,T(A)



```
Search For Text
---------------------
A
---------------------
```

3. Press EXE to begin the search. The contents of the program appear on the screen with the cursor located at the first instance of the data you specified.*1



```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

4. Each press of EXE or F1(SRC) causes the cursor to jump to the next instance of the data you specified.*2

```
======OCTA    ======
?→A:2×√3×A²◢
√2/3×A^3
```

[*1] The message "**Not Found**" appears when the search data you specify cannot be found in the program.

[*2] If there are no more instances of the data you specified, the search operation ends and the cursor returns to the point from which you started your search.

You cannot specify the newline symbol (↵) or display command (◢) for the search data.

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.

If you make a mistake while inputting characters to search for, press AC to clear your input and re-input from the beginning.

8-4 File Management

■ Searching for a File

• To find a file using initial character search

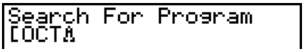
• • • • •

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
[OCTA
```

2. Press EXE to search.

```
Program List
 OCTA          :    44
 OCTONARY      :    89
 TRIANGLE      :    69
```

- The name that starts with the characters you input highlights.

\# 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 ESC to clear the error message.

Editing a file name

● ● ● ● ●

Example To change the name of a file from TRIANGLE to ANGLE

1. While the program list is on the display, use ▲ and ▼ to move the highlighting to the file whose name you want to edit and then press F6(▷)F2(REN).

```
Rename
[ARIANGLE]
```

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.

The program list is resorted according to the changes you made in the file name.

Deleting a Program

• To delete a specific program

1. While the program list is on the display, use ▲ and ▼ to move the highlighting to the name of the program you want to delete.

2. Press F4(DEL).

3. Press EXE(Yes) to delete the selected program or ESC(No) to abort the operation without deleting anything.

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 ESC to clear the error and return to the file name editing screen.
- Press AC to clear the input file name and input a new one.

• To delete all programs

1. While the program list is on the display, press F5(DEL·A).

2. Press EXE(Yes) to delete all the programs in the list or ESC(No) to abort the operation without deleting anything.

- You also can delete all programs by entering the SYSTEM Mode from the Main Menu, and then pressing F1(Mem) to display the memory management screen.
  See "9-2 Memory Operations" for details.

■ Registering a password

When inputting a program, you can protect it with a password that limits access to the program contents to those who know the password.

- You do not need to input the password to run a program.

● ● ● ● ●

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)

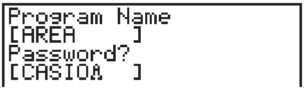
   A R E A

```
Program Name
[AREAA    ]
```

2. Press F5(⊶) and then input the password.

   F5(⊶)

   C A S I O



```
Program Name
[AREA     ]
Password?
[CASIOA   ]
```

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.

4. After inputting the program, press SHIFT ESC (QUIT) to exit the program file and return to the program list. Files that are password protected are indicated by an asterisk to the right of the file name.

```
Program List
 AREA        * :     34
 GRAPHICS      :     56
```

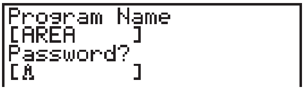
■ Recalling a Password Protected Program

• • • • •

Example **To recall the file named AREA which is protected by the password CASIO**

1. In the program list, use ▲ and ▼ to move the highlighting to the name of the program you want to recall.

2. Press F2 (EDIT).



```
Program Name
[AREA    ]
Password?
[A          ]
```

3. Input the password and press EXE to recall the program.

Pressing EXE without inputting a password while saving a new program causes the file to be saved without a password. Pressing EXE without inputting a password registers the file name only, without a password.

Inputting the wrong password when recalling a password protected program causes the message "**Mismatch**" to appear. Press ESC to return to the password input screen.

8-5 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>, "<prompt>" ? → <variable name>

Example: ? → A

Description:

- This command momentarily interrupts program execution and prompts for input of a value or expression for assignment to a variable. If you do not specify a prompt, execution of this command causes "?" to appear indicating the calculator is standing by for input. If a prompt is specified, "<prompt>?" appears to prompt input. Up to 255 bytes of text can be used for a prompt.

- Input in response to the input command must be a value or an expression, and the expression cannot be a multi-statement.

- You can specify a list name, matrix name, function memory (fn), graph (Yn), etc. as a variable name.

◢ (Output Command)

Function: Displays an intermediate result during program execution.

Description:

- This command momentarily interrupts program execution and displays alpha character text or the result of the calculation immediately before the command.

- 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:

- Unlike the output command (◢), statements connected with the multi-statement command are executed non-stop.

- The multi-statement command can be used to link two calculation expressions or two commands.

- 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:

- Operation of the carriage return is identical to that of the multi-statement command.

- You can create a blank line in a program by inputting a carriage return only. Using a carriage return in place of the multi-statement command makes the displayed program easier to read.

’ (Comment Text Delimiter)

Function: Indicates comment text inserted inside a program.

Description: Anything following the apostrophe is treated as non-executable comment text.

Program Commands (COM)

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:

$$\text{If}\qquad \underset{\text{numeric expression}}{\underline{\text{<condition>}}}\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{Then <statement>}\left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]$$

$$\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\left(\text{Else <statement>}\left[\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\right]\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\right)\text{IfEnd}$$

Parameters: condition, numeric expression

Description:

(1) If ~ Then ~ IfEnd

- When the condition is true, execution proceeds with the Then-statement and then continues with the statement following IfEnd.
- When the condition is false, execution jumps to the statement following IfEnd.

(2) If ~ Then ~ Else ~ IfEnd

- When the condition is true, execution proceeds with the Then-statement and then jumps to the statement following IfEnd.
- When the condition is false, execution jumps to the Else-statement and then continues with the statement following IfEnd.

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:

$$\text{For <starting value>} \rightarrow \text{<control variable name> To <ending value>}\left(\text{Step <step value>}\right)\left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}$$

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 (default: 1)

Description:

- The default step value is 1.

- 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.

Do~LpWhile

Function: This command repeats specific commands as long as its condition is true (non-zero).

Syntax:

$$\text{Do}\ \left\{\begin{matrix}\hookleftarrow\\ :\\ \text{◢}\end{matrix}\right\}\ \text{<statement>}\ \left\{\begin{matrix}\hookleftarrow\\ :\\ \text{◢}\end{matrix}\right\}\ \text{LpWhile}\quad \underset{\text{numeric expression}}{\text{<}\underline{\text{condition}}\text{>}}$$

Parameters: expression

Description:

- 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.

- Since the condition comes after the LpWhile-statement, the condition is tested (checked) after all of the commands inside the loop are executed.

While~WhileEnd

Function: This command repeats specific commands as long as its condition is true (non-zero).

Syntax:

$$\text{While}\quad \underset{\text{numeric expression}}{\langle\underline{\text{condition}}\rangle}\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \langle\text{statement}\rangle\ \left\{\begin{matrix}\text{↵}\\ :\\ \text{◢}\end{matrix}\right\}\ \text{WhileEnd}$$

Parameters: expression

Description:

- 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.

- Since the condition comes after the While-statement, the condition is tested (checked) before the commands inside the loop are executed.

■ 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:

- This command breaks execution of a loop and continues from the next command following the loop.

- This command can be used to break execution of a For-statement, Do-statement, and While-statement.

Prog

Function: This command specifies execution of another program as a subroutine. In the RUN•MAT Mode, this command executes a new program.

Syntax: Prog ”file name”

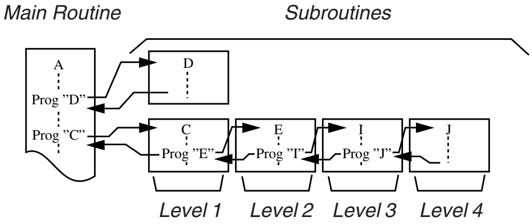
Example: Prog ”ABC”

Description:

- Even when this command is located inside of a loop, its execution immediately breaks the loop and launches the subroutine.

- This command can be used as many times as necessary inside of a main routine to call up independent subroutines to perform specific tasks.

- 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.



- 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.

- 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.

- If a subroutine with the file name specified by the Prog command does not exist, an error occurs.

- In the **RUN•MAT 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. Execution of the Return command within a subroutine terminates the subroutine and returns to the program from which the subroutine was jumped to.

Stop

Function: This command terminates execution of a program.

Syntax: Stop

Description:

- This command terminates program execution.

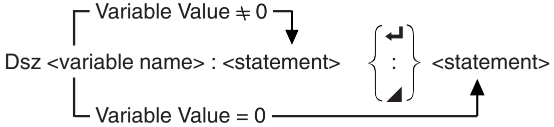
- Execution of this command inside of a loop terminates program execution without an error being generated.

■ 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 (↵).

Goto~Lbl

Function: This command performs an unconditional jump to a specified location.

Syntax: Goto <label name> ~ Lbl <label name>

Parameters: label name: value (0 to 9), variable (A to Z, r, θ)

Description:

- This command consists of two parts: Goto n (where n is a parameter as described above) and Lbl n (where n is the parameter referenced by Goto n). This command causes program execution to jump to the Lbl-statement whose n parameter matches that specified by the Goto-statement.

- This command can be used to loop back to the beginning of a program or to jump to any location within the program.

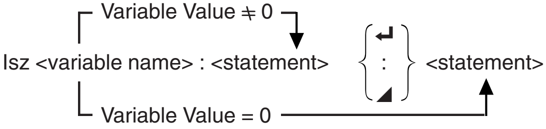
- This command can be used in combination with conditional jumps and count jumps.

- If there is no Lbl-statement whose value matches that specified by the Goto-statement, an error occurs.

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 (↵).

■ Clear Commands (CLR)

ClrGraph

Function: This command clears the graph screen and returns View Window settings to their INIT values.

Syntax: ClrGraph

Description: This command clears the graph screen during program execution.

ClrList

Function: This command deletes list data.

Syntax: ClrList <list name>

ClrList

Parameters: list name: 1 to 20, Ans

Description: This command deletes the data in the list specified by “list name”. All list data is deleted if nothing is specified for “list name”.

ClrText

Function: This command clears the text screen.

Syntax: ClrText

Description: This command clears text from the screen during program execution.

ClrMat

Function: This command deletes matrix data.

Syntax: ClrMat <matrix name>
ClrMat

Parameters: matrix name: A to Z, Ans

Description: This command deletes the data in the matrix specified by “matrix name”. All matrix data is deleted if nothing is specified for “matrix name”.

■ Display Commands (DISP)

DispF-Tbl, DispR-Tbl **No parameters**

Function: These commands display numeric tables.

Description:

- These commands generate numeric tables during program execution in accordance with conditions defined within the program.

- DispF-Tbl generates a function table, while DispR-Tbl generates a recursion table.

DrawDyna **No parameters**

Function: This command executes a Dynamic Graph draw operation.

Description: This command draws a Dynamic Graph during program execution in accordance with current Dynamic Graph parameters.

DrawFTG-Con, DrawFTG-Plt **No parameters**

Function: This command uses values in a generated table to graph a function.

Description:

- This command draws a function graph in accordance with current conditions.
- DrawFTG-Con produces a connect type graph, while DrawFTG-Plt produces a plot type graph.

DrawGraph **No parameters**

Function: This command draws a graph.

Description:

- This command draws a graph in accordance with current conditions.

DrawR-Con, DrawR-Plt **No parameters**

Function: These commands use values in a generated table to graph a recursion expression with a_n(b_n or c_n) as the vertical axis and n as the horizontal axis.

Description:

- These commands graph recursion expressions in accordance with current conditions, with a_n(b_n or c_n) as the vertical axis and n as the horizontal axis.

- DrawR-Con produces a connect type graph, while DrawR-Plt produces a plot type graph.

DrawRΣ-Con, DrawRΣ-Plt

No parameters

Function: These commands use values in a generated table to graph a recursion expression with Σa_n(Σb_n or Σc_n) as the vertical axis and n as the horizontal axis.

Description:

- These commands graph recursion expressions in accordance with current conditions, with Σa_n(Σb_n or Σc_n) as the vertical axis and n as the horizontal axis.

- DrawRΣ-Con produces a connect type graph, while DrawRΣ-Plt produces a plot type graph.

DrawStat

Function: This draws a statistical graph.

Syntax: See “8-6-9 Using Statistical Calculations and Graphs in a Program”.

Description:

This command draws a statistical graph in accordance with current statistical graph conditions.

DrawWeb

Function: This command graphs convergence/divergence of a recursion expression (WEB graph).

Syntax: DrawWeb <recursion type>, <number of lines>

Example: DrawWeb a_{n+1} (b_{n+1} or c_{n+1}), 5

Description:

- This command graphs convergence/divergence of a recursion expression (WEB graph).

- Omitting the number of lines specification automatically specifies the default value 30.

■ Input/Output Commands (I/O)

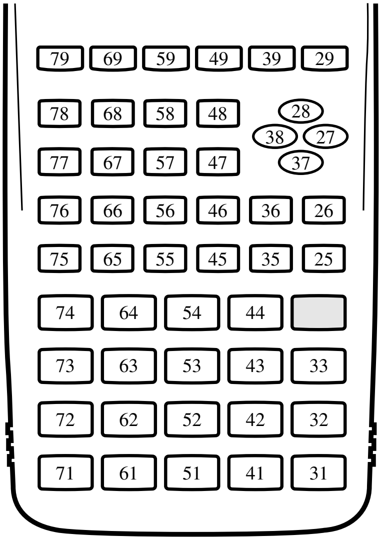
Getkey

Function: This command returns the code that corresponds to the last key pressed.

Syntax: Getkey

Description:

- This command returns the code that corresponds to the last key pressed.



- A value of zero is returned if no key was pressed previous to executing this command.

- 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>, <numeric expression>

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 and numeric expression
- string: character string

Description:

- This command displays values (including variable contents) or text at a specific location on the text screen. If there is a calculation input, that calculation result is displayed.
- The line is designated by a value from 1 to 7, while the column is designated 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 (/ Send (

Function: This command receives data from and sends data to a connected device.

Syntax: Receive (<data>) / Send (<data>)

Description:

- This command receives data from and sends data to a connected device.

- The following types of data can be received (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>

Parameters:

left side/right side: variable (A to Z, r, θ), numeric constant, variable expression (such as: A × 2)

relational operator: =, ≠, >, <, ≥, ≤

8-6 Using Calculator Functions in Programs

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**
”CASIO”	CASIO
? → 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 exceeds 21 characters.
- You can specify up to 255 bytes of text for a comment.

Using Matrix Row Operations in a Program

These commands let you manipulate the rows of a matrix in a program.

- For this program, enter the **RUN • MAT Mode** and then use the MAT Editor to input the matrix, and then enter 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.

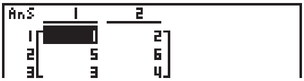
Swap A, 2, 3↵

Rows to be swapped

Matrix name

Mat A

Executing this program produces the following result.



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

• To calculate a scalar multiplication (∗Row)

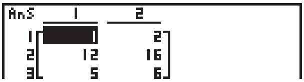
● ● ● ● ●

Example 2 To calculate the product of Row 2 of the matrix in Example 1 and the scalar 4

The following is the syntax to use for this program.

∗Row 4, A, 2↵
Row
Matrix name
Multiplier
Mat A

Executing this program produces the following result.



```
AnS    1      2
 1[           2]
 2     12    16
 3[     5     6]
```

• To calculate a scalar multiplication and add the results to another row (∗Row+)

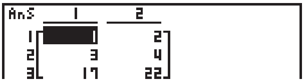
● ● ● ● ●

Example 3 To calculate the product of Row 2 of the matrix in Example 1 and the scalar 4, then add the result to row 3

The following is the syntax to use for this program.

∗Row+ 4, A, 2, 3↵
Rows to be added
Row for which scalar multiplication is to be calculated.
Matrix name
Multiplier
Mat A

Executing this program produces the following result.



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

• To add two rows (Row+)

● ● ● ● ●

Example 4 To add Row 2 to Row 3 of the matrix in Example 1

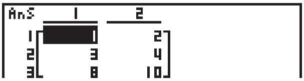
The following is the syntax to use for this program.

Row+ A, 2, 3↵

3: *the row number to be added to*
2: *the row number to be added*
A: *Matrix name*

Mat A

Executing this program produces the following result.



```
Ans   1      2
 1 [  1      2 ]
 2    3      4
 3 [  8     10 ]
```

■ 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↵

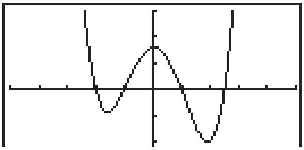
- Graph draw operation

  DrawGraph↵

Example Program

①ClrGraph↵	① SHIFT VARS F6 F6 F1 2 ESC
②View Window –10, 10, 2, –120, 150, 50↵	② SHIFT OPTN F1 ESC
③Y = Type↵	③ F6 F1 3 1
”X^4–X^3–24X^2 + 4X + 80” ➡ $\underset{④}{\underline{\text{Y1}}}$↵	④ VARS F4 1 ESC
⑤G SelOn 1↵	⑤ F6 F1 1
⑥DrawGraph	⑥ SHIFT VARS F6 F6 F2 2

Executing this program produces the result shown here.



• Syntax of other graphing functions

- V-Window

  View Window <Xmin>, <Xmax>, <Xscale>, <Ymin>, <Ymax>, <Yscale>, <Tθmin>, <Tθmax>, <Tθpitch>

  StoV-Win <area of V-Win> .... area: 1 to 6

  RclV-Win <area of V-Win> .... area: 1 to 6

- Zoom

  Factor <X factor>, <Y factor>

  ZoomAuto .... Non-parameter

- Pict

  StoPict <area of picture> .... area: 1 to 20

  RclPict <area of picture> .... area: 1 to 20

- Sketch

  PlotOn <X-coordinate>, <Y-coordinate>

  PlotOff <X-coordinate>, <Y-coordinate>

  PlotChg <X-coordinate>, <Y-coordinate>

  PxlOn<line number>, <column number>

  PxlOff<line number>, <column number>

  PxlChg<line number>, <column number>

  PxlTest(<line number>, <column number>[)]

  F-Line <X-coordinate 1>, <Y-coordinate 1>, <X-coordinate 2>, <Y-coordinate 2>

  Text <line number>, <column number>, ”<text>”

  Text <line number>, <column number>, <expression>

  Tangent <function>, <X-coordinate>

  Normal <function>, <X-coordinate>

  Inverse <function>

  Circle <center point X-coordinate>, <center point Y-coordinate>, <radius R value>

  Vertical <X-coordinate>

  Horizontal <Y-coordinate>

Using Dynamic Graph Functions in a Program

Using Dynamic Graph functions in a program makes it possible to perform repeated Dynamic Graph operations. The following shows how to specify the Dynamic Graph range inside a program.

- **Dynamic Graph range**

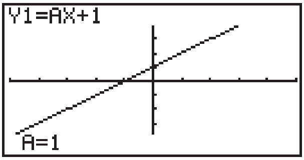
1 → D Start↵
5 → D End↵
1 → D pitch↵

Example Program

ClrGraph↵
View Window –5, 5, 1, –5, 5, 1↵
Y = Type↵

”AX + 1” → $\underset{①}{\text{Y}}$1↵	① VARS F4 1 ESC
②D SelOn 1↵	② F6 F2 1
③D Var A↵	③ F2 3
1 → ④D Start↵	④ VARS F5 1
5 → ⑤D End↵	⑤ F5 2
1 → ⑥D pitch↵	⑥ F5 3
⑦DrawDyna	⑦ SHIFT VARS F6 F6 F2 3

Executing this program produces the result shown here.



⋮ ↑
↓ ⋮

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.

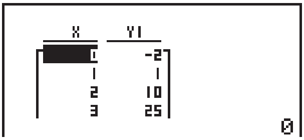
- Table range setting
```
1 → F Start↵
5 → F End↵
1 → F pitch↵
```
- Numeric table generation
```
DispF-Tbl↵
```
- Graph draw operation
```
Connect type: DrawFTG-Con↵
Plot type: DrawFTG-Plt↵
```

Example Program

```
  ClrGraph↵
  ClrText↵
  View Window 0, 6, 1, –20, 106, 10↵
  Y = Type↵
  "3X² – 2" → Y1↵
① G SelOn 1↵                  ① F6 F1 1
  0 → ② F Start↵              ② VARS F6 F1 1
  6 → ③ F End↵                ③ F1 2
  1 → ④ F pitch↵              ④ F1 3
⑤ DispF-Tbl◢                  ⑤ SHIFT VARS F6 F6 F2 4 1
⑥ DrawFTG-Con                 ⑥ SHIFT VARS F6 F6 F2 4 2
```

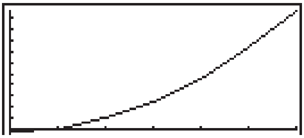
Executing this program produces the results shown here.

Numeric Table



```
   X     Y1
   0     -2
   1      1
   2     10
   3     25
                  0
```

Graph



■ 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↵

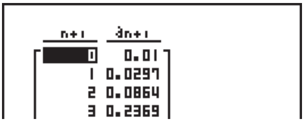
Example Program

View Window 0, 1, 1, –0.2, 1, 1↵
① a_{n+1} Type↵
”–3$\overset{②}{a_n}^2$ + 3a_n” → $\overset{③}{a_{n+1}}$↵
0 → $\overset{④}{\text{R}}$ Start↵
6 → $\overset{⑤}{\text{R}}$ End↵
0.01 → $\overset{⑥}{a_0}$↵
0.01 → $\overset{⑦}{a_n}$ Start↵
⑧ DispR-Tbl◢
⑨ DrawWeb $\overset{⑩}{a_{n+1}}$, 30

① F6 F3 6 2
② F3 1 2
③ F3 1 3
④ VARS F6 F2 2 1
⑤ F2 2 2
⑥ F2 2 3
⑦ F2 2 C
⑧ SHIFT VARS F6 F6 F2 5 1
⑨ F2 5 2 ESC
⑩ F6 F3 1 3

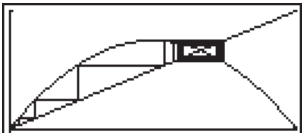
Executing this program produces the results shown here.

Numeric Table



n+1	an+1
0	0.01
1	0.0297
2	0.0864
3	0.2369

Recursion graph



Using List Sort Functions in a Program

These functions let you sort data in lists into ascending or descending order.

- Ascending order

①SortA (②List 1, List 2, List 3)
Lists to be sorted (up to six can be specified)

① F5 1 ② F4 4

- Descending order

③SortD (List 1, List 2, List 3)
Lists to be sorted (up to six can be specified)

③ F5 2

Using Solve Calculation Function in a Program

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

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

Upper limit (b)
Lower limit (a)
Initial estimated value (n)

Example Program

①Solve($2X^2 + 7X - 9$, 1, 0, 1)　　　① OPTN F4 7

- In the function $f(x)$, only X can be used as a variable in the expression. 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.

Using Statistical Calculations and Graphs in a Program

Including statistical calculations and graphing operations in a 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

Solutions obtained using Solve may include errors.

You cannot use a differential, quadratic differential, integration, Σ , maximum/minimum value or Solve calculation expressions inside of a Solve calculation term.

The graph conditions that are required depends on the graph type. See “Changing Graph Parameters” (page 6-1-2).

- The following is a typical graph condition specification for a scatter diagram or *xy*Line graph.

  S-Gph1 DrawOn, Scatter, List 1, List 2, 1, Square ↵

  In the case of an *xy* line graph, replace “Scatter” in the above specification with “*xy*Line”.

- The following is a typical graph condition specification for a normal probability plot.

  S-Gph1 DrawOn, NPPlot, List 1, Square ↵

- The following is a typical graph condition specification for a single-variable graph.

  S-Gph1 DrawOn, Hist, List 1, List 2 ↵

  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.

  Histogram: .... Hist
  Median Box: .... MedBox
  Modified Box: .... Modified
  Normal Distribution: .... N-Dist
  Broken Line: .... Broken

- The following is a typical graph condition specification for a regression graph.

  S-Gph1 DrawOn, Linear, List 1, List 2, List 3 ↵

  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.

  Linear Regression: .... Linear
  Med-Med: .... Med-Med
  Quadratic Regression: .... Quad
  Cubic Regression: .... Cubic
  Quartic Regression: .... Quart
  Logarithmic Regression: .... Log
  Exponential Regression: .... Exp
  Power Regression: .... Power

- The following is a typical graph condition specification for a sinusoidal regression graph.

  S-Gph1 DrawOn, Sinusoidal, List 1, List 2 ↵

- The following is a typical graph condition specification for a logistic regression graph.

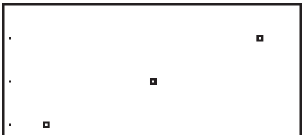
  S-Gph1 DrawOn, Logistic, List 1, List 2 ↵

Example Program

```
ClrGraph↵
①
S-Wind Auto↵

{1, 2, 3} → List 1↵

{1, 2, 3} → List 2↵
②      ③       ④                      ⑤
S-Gph1 DrawOn, Scatter, List 1, List 2, 1, Square ↵
⑥
DrawStat
```

① CTRL F3 F5 1 1 ESC
② F4 1 1
③ F4 2 1
④ F4 3 1
⑤ F4 5 1
⑥ SHIFT VARS F6 F6 F2 1

Executing this program produces the scatter diagram shown here.



■ Performing Statistical Calculations

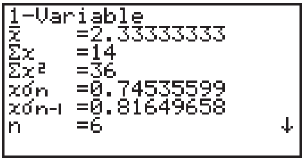
- Single-variable statistical calculation

  ①1-Variable List 1, List 2

  List 2 — *Frequency data (Frequency)*

  List 1 — *x-axis data (XList)*

  ① F4 6 1



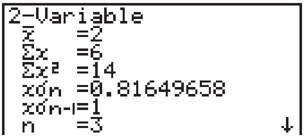
```
1-Variable
x̄     =2.33333333
Σx    =14
Σx²   =36
xσn   =0.74535599
xσn-1 =0.81649658
n     =6          ↓
```

- Paired-variable statistical calculation

①2-Variable List 1, List 2, List 3

Frequency data (Frequency)
y-axis data (YList)
x-axis data (XList)

① F4 6 2



```
2-Variable
 x̄    =2
 Σx   =6
 Σx²  =14
 xσn  =0.81649658
 xσn-1=1
 n    =3           ↓
```

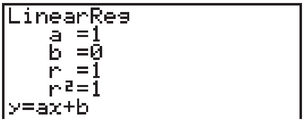
- Regression statistical calculation

①LinearReg List 1, List 2, List 3

*Calculation type**

Frequency data (Frequency)
y-axis data (YList)
x-axis data (XList)

① F4 6 3



```
LinearReg
   a =1
   b =0
   r =1
   r²=1
y=ax+b
```

* Any one of the following can be specified as the calculation type.

LinearReg .... linear regression
Med-MedLine .... Med-Med calculation
QuadReg .... quadratic regression
CubicReg .... cubic regression
QuartReg .... quartic regression
LogReg .... logarithmic regression
ExpReg .... exponential regression
PowerReg .... power regression

- Sinusoidal regression statistical calculation

SinReg List 1, List 2

y-axis data (YList)
x-axis data (XList)

- Logistic regression statistical calculation

LogisticReg List 1, List 2

y-axis data (YList)
x-axis data (XList)

8-7 Program Mode Command List

RUN Program

Level 1	Level 2	Level 3	Command
MAT	Swap		**Swap_**
	*Row		*Row_
	*Row+		*Row+_
	Row+		**Row+_**
STAT	S-GPH	S-Gph1	**S-Gph1_**
		S-Gph2	**S-Gph2_**
		S-Gph3	**S-Gph3_**
	DRAW	On	**DrawOn**
		Off	**DrawOff**
	GRAPH	Scat	**Scatter**
		xyLine	**xyLine**
		NPPlot	**NPPlot**
		Hist	**Hist**
		Box	**MedBox**
		ModBox	**ModifiedBox**
		N-Dist	**N-Dist**
		Broken	**Broken**
		Linear	**Linear**
		MedMed	**Med-Med**
		Quad	**Quad**
		Cubic	**Cubic**
		Quart	**Quart**
		Log	**Log**
		Exp	**Exp**
		Power	**Power**
		Sin	**Sinusoidal**
		Lgstic	**Logistic**
	List		**List_**
	MARK	□	**Square**
		×	**Cross**
		•	**Dot**
	CALC	1VAR	**1-Variable_**
		2VAR	**2-Variable_**
		Linear	**LinearReg_**
		MedMed	**Med-MedLine_**
		Quad	**QuadReg_**
		Cubic	**CubicReg_**
		Quart	**QuartReg_**
		Log	**LogReg_**
		Exp	**ExpReg_**
		Power	**PowerReg_**
		Sin	**SinReg_**
		Lgstic	**LogisticReg_**
LIST	SortA		**SortA(**
	SortD		**SortD(**
GRPH	SelOn		**G_SelOn_**
	SelOff		**G_SelOff_**
	TYPE	Y=	**Y=TYPE**
		r=	**r=TYPE**
		Param	**ParamTYPE**
		X=c	**X=cTYPE**
		Y>	**Y>Type**
		Y<	**Y<Type**
		Y≧	**Y≥Type**
		Y≦	**Y≤Type**
	GMEM	Store	**StoGMEM**
		Recall	**RclGMEM**
DYNA	SelOn		**D_SelOn_**
	SelOff		**D_SelOff_**
	Var		**D_Var_**
	TYPE	Y=	**Y=Type**
		r=	**r=Type**
		Param	**ParamType**
RECR	n,an..	n	**n**
		an	**an**
		an+1	**an+1**
		bn	**bn**
		bn+1	**bn+1**
		cn	**cn**
		cn+1	**cn+1**
	SelOn		**R_SelOn_**
	SelOff		**R_SelOff_**
	Sel a$_0$		**Sel_a$_0$**
	Sel a$_1$		**Sel_a$_1$**
	TYPE	an	**anType**
		an+1	**an+1Type**
		an+2	**an+2Type**

[OPTN] key

Level 1	Level 2	Level 3	Command
LIST	List		**List_**
	Dim		**Dim_**
	Seq		**Seq(**
	Min		**Min(**
	Max		**Max(**
	Mean		**Mean(**
	Median		**Median(**
	Sum		**Sum_**
	Prod		**Prod_**
	Cuml		**Cuml_**
	%		**Percent_**
	⊿List		**⊿List_**
	Augmnt		**Augment(**
	Fill		**Fill(**
	L→Mat		**List→Mat(**
MAT	Mat		**Mat_**
	Dim		**Dim_**
	Det		**Det_**
	Trn		**Trn_**
	Augmnt		**Augment(**
	Ident		**Identity_**
	Fill		**Fill(**
	M→List		**Mat→List(**
CPLX	Abs		**Abs_**
	Arg		**Arg_**
	Conjg		**Conjg_**
	ReP		**ReP_**
	ImP		**ImP_**
	▸re^θi		**▸re^θ i**
	▸a+bi		**▸a+bi**
CALC	d/dx		**d/dx(**
	d^2/dx^2		**d^2/dx^2(**
	∫dx		**∫(**
	Σ		**Σ(**
	FMin		**FMin(**
	FMax		**FMax(**
	Solve		**Solve(**
NUM	Abs		**Abs_**
	Int		**Int_**
	Frac		**Frac_**
	Rnd		**Rnd**
	Intg		**Intg_**
	E-SYM	m	**m**
		μ	μ
		n	**n**
		p	**p**
		f	**f**
		k	**k**
		M	**M**
		G	**G**
		T	**T**
		P	**P**
		E	**E**
PROB	x!		**!**
	nPr		**P**
	nCr		**C**
	Ran#		**Ran#_**
	P(		**P(**
	Q(		**Q(**
	R(		**R(**
	t(		**t(**
HYP	sinh		**sinh_**
	cosh		**cosh_**
	tanh		**tanh_**
	sinh^{-1}		**sinh^{-1}_**
	cosh^{-1}		**cosh^{-1}_**
	tanh^{-1}		**tanh^{-1}_**
ANGL	°		°
	r		**r**
	g		**g**
	° ’ ”		° ’ ”
	▸DMS		**▸DMS**
	Pol(		**Pol(**
	Rec(		**Rec(**
STAT	$\hat{x}$		$\hat{x}$
	$\hat{y}$		$\hat{y}$
FMEM	fn		**fn**
ZOOM	Factor		**Factor_**
	Auto		**ZoomAuto**
SKTCH	Cls		**Cls**
	PLOT	On	**PlotOn_**
		Off	**PlotOff_**
		Change	**PlotChg_**
		Plot	**Plot_**
	LINE	F-Line	**F-Line_**
		Line	**Line**
	GRAPH	Y=	**Graph_Y=**
		∫dx	**Graph_∫**
	Text		**Text_**
	PIXEL	On	**PxlOn_**
		Off	**PxlOff_**
		Change	**PxlChg_**
		Test	**PxlTest(**
	Tangnt		**Tangent_**
	Normal		**Normal_**
	Invrse		**Inverse_**
	Circle		**Circle_**
	Vert		**Vertical_**
	Horz		**Horizontal_**
PICT	Store		**StoPict_**
	Recall		**RclPict_**
SYBL	’		’
	”		”
	~		~
	✻		✻
	#		#
° ’ ”			□

[VARS] key

Level 1	Level 2	Level 3	Command
V-WIN	Xmin		**Xmin**
	Xmax		**Xmax**
	Xscale		**Xscl**
	Xdot		**Xdot**
	Ymin		**Ymin**
	Ymax		**Ymax**
	Yscale		**Yscl**
	Tθmin		**Tθmin**
	Tθmax		**Tθmax**
	Tθptch		**Tθptch**
	R-Xmin		**RightXmin**
	R-Xmax		**RightXmax**
	R-Xscl		**RightXscl**
	R-Xdot		**RightXdot**
	R-Ymin		**RightYmin**
	R-Ymax		**RightYmax**
	R-Yscl		**RightYscl**
	R-Tmin		**RightT θmin**
	R-Tmax		**RightT θmax**
	R-Tpch		**RightT θptch**
FACT	Xfact		**Xfct**
	Yfact		**Yfct**
STAT	n		**n**
	X	$\bar{x}$	**$\bar{x}$**
		Σx	**Σx**
		Σx^2	**Σx^2**
		xσn	**xσn**
		xσn–1	**xσn–1**
		minX	**minX**
		maxX	**maxX**
	Y	$\bar{y}$	**$\bar{y}$**
		Σy	**Σy**
		Σy^2	**Σy^2**
		Σxy	**Σxy**
		yσn	**yσn**
		yσn–1	**yσn–1**
		minY	**minY**
		maxY	**maxY**
	GRAPH	a	**a**
		b	**b**
		c	**c**
		d	**d**
		e	**e**
		r	**r**
		r^2	**r^2**
		Q1	**Q1**
		Med	**Med**
		Q3	**Q3**
		Mod	**Mod**
		H-Strt	**H_Start**
		H-ptch	**H_pitch**
	PTS	x1	**x1**
		y1	**y1**
		x2	**x2**
		y2	**y2**
		x3	**x3**
		y3	**y3**
GRPH	Yn		**Y**
	rn		**r**
	Xtn		**Xt**
	Ytn		**Yt**
	Xn		**X**
DYNA	Start		**D_Start**
	End		**D_End**
	Pitch		**D_pitch**
TABL	Start		**F_Start**
	End		**F_End**
	Pitch		**F_pitch**
	Result		**F_Result**
RECR	FORM	an	**an**
		an+1	**an+1**
		an+2	**an+2**
		bn	**bn**
		bn+1	**bn+1**
		bn+2	**bn+2**
		cn	**cn**
		cn+1	**cn+1**
		cn+2	**cn+2**
	RANGE	R-Strt	**R_Start**
		R-End	**R_End**
		a0	**a0**
		a1	**a1**
		a2	**a2**
		b0	**b0**
		b1	**b1**
		b2	**b2**
		c0	**c0**
		c1	**c1**
		c2	**c2**
		anStrt	**anStart**
		bnstrt	**bnStart**
		cnStrt	**cnStart**
	Result		**R_Result**
EQUA	S-Rslt		**Sim_Result**
	S-Coef		**Sim_Coef**
	P-Rslt		**Ply_Result**
	P-Coef		**Ply_Coef**

[SHIFT][VARS](PRGM) key

Level 1	Level 2	Level 3	Command
Prog			**Prog_**
JUMP	Lbl		**Lbl_**
	Goto		**Goto_**
	Isz		**Isz_**
	Dsz		**Dsz_**
?			**?**
◢			**◢**
I/O	Locate		**Locate_**
	Getkey		**Getkey**
	Send		**Send(**
	Receiv		**Receive(**
IF	If		**If_**
	Then		**Then_**
	Else		**Else_**
	IfEnd		**IfEnd**
FOR	For		**For_**
	To		**_To_**
	Step		**_Step_**
	Next		**Next**
WHLE	While		**While_**
	WhlEnd		**WhileEnd**
	Do		**Do**
	LpWhle		**LpWhile_**
CTRL	Prog		**Prog_**
	Return		**Return**
	Break		**Break**
	Stop		**Stop**
LOGIC	=≠<	=	**=**
		≠	**≠**
		>	**>**
		<	**<**
		≧	**≧**
		≦	**≦**
	And		**_And_**
	Or		**_Or_**
	Not		**Not_**
CLR	Text		**ClrText**
	Graph		**ClrGraph**
	List		**ClrList_**
	Matrix		**ClrMat_**
DISP	Stat		**DrawStat**
	Graph		**DrawGraph**
	Dyna		**DrawDyna**
	F-TBL	Table	**DispF-Tbl**
		G-Con	**DrawFTG-Con**
		G-Plot	**DrawFTG-Plt**
	R-TBL	Table	**DispR-Tbl**
		Web	**DrawWeb_**
		R-Con	**DrawR-Con**
		RΣ-Con	**DrawRΣ-Con**
		R-Plot	**DrawR-Plt**
		RΣ-Plt	**DrawRΣ-Plt**
:			**:**

[CTRL][F3](SET UP) key

Level 1	Level 2	Level 3	Command
ANGL	Deg		**Deg**
	Rad		**Rad**
	Gra		**Gra**
DISP	Fix		**Fix_**
	Sci		**Sci_**
	Norm		**Norm**
	EngOn		**EngOn**
	EngOff		**EngOff**
CPLX	Real		**Real**
	a+bi		**a+bi**
	$re^\wedge\theta i$		**$re^\wedge\theta i$**
GRPH	G-FUNC	On	**FuncOn**
		Off	**FuncOff**
	D-TYPE	G-Con	**G-Connect**
		G-Plot	**G-Plot**
	BG	None	**BG-None**
		Pict	**BG-Pict_**
	SIMUL	On	**SimulOn**
		Off	**SimulOff**
	COORD	On	**CoordOn**
		Off	**CoordOff**
	GRID	On	**GridOn**
		Off	**GridOff**
	AXES	On	**AxesOn**
		Off	**AxesOff**
	LABEL	On	**LabelOn**
		Off	**LabelOff**
STAT	S-WIN	Auto	**S-WindAuto**
		Manual	**S-WindMan**
	File		**File_**
	RESID	None	**Resid-None**
		List	**Resid-List_**
DERIV	On		**DerivOn**
	Off		**DerivOff**
T-VAR	Range		**VarRange**
	List		**VarList_**
Σ•DSP	On		**ΣdispOn**
	Off		**ΣdispOff**

BASE Program

[SHIFT][OPTN](V-Window)key

Level 1	Level 2	Level 3	Command
V-Win			**ViewWindow_**
Sto			**StoV-Win_**
Rcl			**RclV-Win_**

Level 1	Level 2	Level 3	Command
d~o	d		**d**
	h		**h**
	b		**b**
	o		**o**
LOG	Neg		**Neg_**
	Not		**Not_**
	and		**and**
	or		**or**
	xor		**xor**
	xnor		**xnor**
DISP	▸Dec		**▸Dec**
	▸Hex		**▸Hex**
	▸Bin		**▸Bin**
	▸Oct		**▸Oct**

[CTRL][F3](SETUP) key

Level 1	Level 2	Level 3	Command
Dec			**Dec**
Hex			**Hex**
Bin			**Bin**
Oct			**Oct**

[SHIFT][VARS](PRGM) key

Level 1	Level 2	Level 3	Command
Prog			**Prog_**
JUMP	Lbl		**Lbl_**
	Goto		**Goto_**
	Isz		**Isz_**
	Dsz		**Dsz_**
?			**?**
◢			**◢**
= ≠ <	=		**=**
	≠		**≠**
	>		**>**
	<		**<**
	≧		**≧**
	≦		**≦**
:			**:**

8-8 Program Library

- Be sure to check how many bytes of unused memory are remaining before attempting to perform any programming.

Program Name **Prime Factorization**

Description

This program continually divides a natural number by factors until all its prime factors are produced.

Purpose

This program accepts input of natural number A, and divides it by B (2, 3, 5, 7....) to find the prime factors of A.

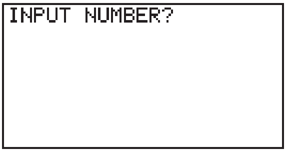
- If a division operation does not produce a remainder, the result of the operation is assigned to A.
- The above procedure is repeated until B > A.

● ● ● ● ●

Example

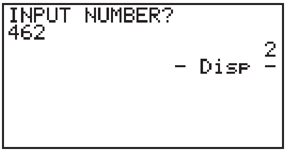
440730 = 2 × 3 × 3 × 5 × 59 × 83

```
ClrText↵
"INPUT NUMBER"?→A↵
2→B↵
Do↵
While Frac (A/B)=0↵
B◢
A/B→A↵
WhileEnd↵
If B=2↵
Then 3→B↵
Else B+2→B↵
IfEnd↵
LpWhile B≤A↵
"END"
```



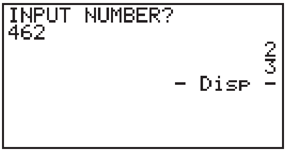
```
INPUT NUMBER?
```

4 6 2 EXE



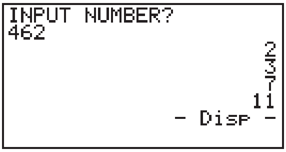
```
INPUT NUMBER?
462
                 2
           - Disp -
```

EXE



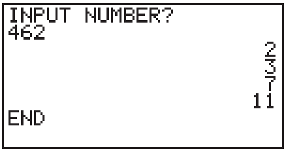
```
INPUT NUMBER?
462
                 2
                 3
           - Disp -
```

EXE EXE



```
INPUT NUMBER?
462
                 2
                 3
                 7
                11
           - Disp -
```

EXE



```
INPUT NUMBER?
462
                 2
                 3
                 7
                11
END
```

Program Name Arithmetic-Geometric Sequence Differentiation

Description

After inputting sequence terms 1, 2, and 3, this program determines whether it is an arithmetic sequence or geometric sequence based on the differences and ratios of the terms.

Purpose

This program determines whether a specific sequence is an arithmetic sequence or geometric sequence.

● ● ● ● ●

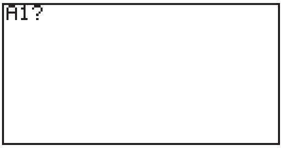
Example 1 5, 10, 15, ... Arithmetic sequence

● ● ● ● ●

Example 2 5, 10, 20, ... Geometric sequence

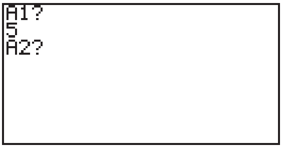
```
ClrText↵
"A1"?→A↵
"A2"?→B↵
"A3"?→C↵
B-A→D↵
C-B→E↵
If D=E↵
Then ClrText↵
"AN = A1 + (N-1)D"↵
" "↵
"A1 ="↵
"D  ="↵
Locate 6,3,A↵
Locate 6,4,D◢
IfEnd↵
B/A→F↵
C/B→G↵
If F=G↵
Then ClrText↵
"AN = A1×r^(N-1)"↵
" "↵
"A1 ="↵
"r  ="↵
Locate 6,3,A↵
Locate 6,4,F↵
IfEnd↵
"END"
```

Example 1



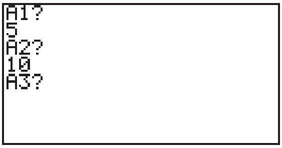
```
A1?
```

5 EXE



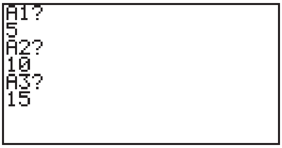
```
A1?
5
A2?
```

1 0 EXE



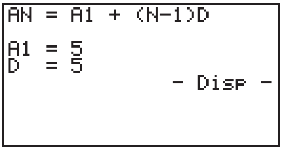
```
A1?
5
A2?
10
A3?
```

1 5



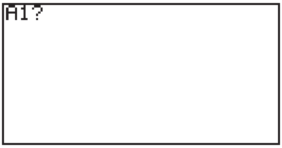
```
A1?
5
A2?
10
A3?
15
```

EXE



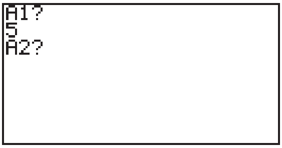
```
AN = A1 + (N-1)D

A1 = 5
D  = 5
                - Disp -
```

Example 2



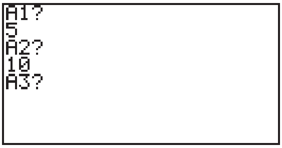
```
A1?
```

5 EXE



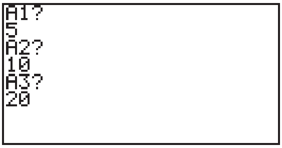
```
A1?
5
A2?
```

1 0 EXE



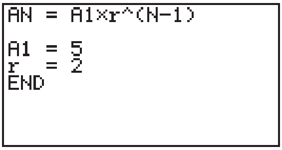
```
A1?
5
A2?
10
A3?
```

2 0



```
A1?
5
A2?
10
A3?
20
```

EXE



```
AN = A1×r^(N-1)

A1 = 5
r  = 2
END
```

Program Name Ellipse

Description

This program displays a number table of the following values based on input of the foci of an ellipse, the sum of the distance between the loci and foci, and the pitch (step size) of X.

Y1: Coordinate values of upper half of ellipse
Y2: Coordinate values of lower half of ellipse
Y3: Distances between right focus and loci
Y4: Distances between left focus and loci
Y5: Sum of Y3 and Y4

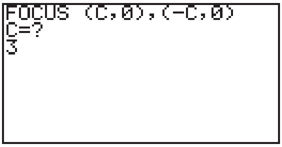
Next, the program plots the foci and values in Y1 and Y2.

Purpose

This program shows that the sums of the distances between the loci and two foci of an ellipse are equal.

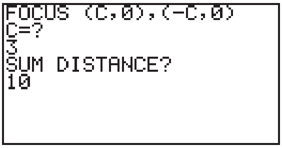
```
Do↵
ClrText↵
"FOCUS (C,0),(-C,0)"↵
"C="?→C↵
"SUM DISTANCE"?→D↵
LpWhile 2Abs C≥D Or D≤0↵
D/2→A↵
√(A²-C²)→B↵
Y=Type↵
"B√(1-X²/A²)"→Y1↵
"-Y1"→Y2↵
"√((X-C)²+Y1²)"→Y3↵
"√((X+C)²+Y1²)"→Y4↵
"Y3+Y4"→Y5↵
For 1→E To 20↵
If E≤5↵
Then G SelOn E↵
Else G SelOff E↵
IfEnd↵
Next↵
-Int A→F Start↵
Int A→F End↵
"F pitch"?→F pitch↵
DispF-Tbl◢
ClrGraph↵
1.2A→Xmax↵
-1.2A→Xmin↵
1.2B→Ymax↵
-1.2B→Ymin↵
G SelOff 3↵
G SelOff 4↵
G SelOff 5↵
DispF-Tbl↵
DrawFTG-Plt↵
PlotOn C,0↵
PlotOn -C,0◢
"END"
```

3



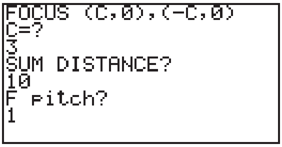
```
FOCUS (C,0),(-C,0)
C=?
3
```

EXE 1 0



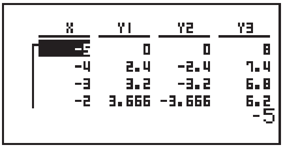
```
FOCUS (C,0),(-C,0)
C=?
3
SUM DISTANCE?
10
```

EXE 1



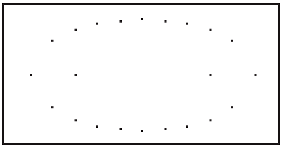
```
FOCUS (C,0),(-C,0)
C=?
3
SUM DISTANCE?
10
F pitch?
1
```

EXE



```
      X      Y1      Y2     Y3
     -5       0       0      8
     -4     2.4    -2.4    7.4
     -3     3.2    -3.2    6.8
     -2   3.666  -3.666    6.2
                            -5
```

EXE CTRL 0



Program Name Rotation

Description

This program draws an angle at the coordinate defined by an input vertex, and then rotates it to a specified angle around the vertex.

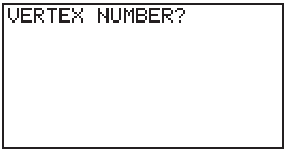
Purpose

This program demonstrates coordinate transformation using a matrix.

Important!

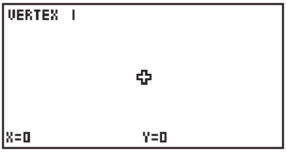
Deg must be set as the angle unit for this program.

```
Do↵
ClrText↵
"VERTEX NUMBER"?→A↵
LpWhile A≤0 Or Frac A≠0↵
{2,A}→Dim Mat A↵
ClrGraph↵
For 1→B To A↵
Text 1,1,"VERTEX"↵
Text 1,30,B↵
If B=1↵
Then Plot ◢
PlotOn X,Y↵
X→Mat A[1,B]↵
Y→Mat A[2,B]↵
Else Plot C,D◢
F-Line C,D,X,Y↵
X→Mat A[1,B]↵
Y→Mat A[2,B]↵
IfEnd↵
Mat A[1,B]→C↵
Mat A[2,B]→D↵
Next↵
Mat A[1,1]→E↵
Mat A[2,1]→F↵
F-Line C,D,E,F↵
Text 1,1,"--AXIS--"↵
Plot ◢
PlotOn X,Y↵
X→C↵
Y→D↵
A→Dim List 1↵
A→Dim List 2↵
Fill(C,List 1)↵
Fill(D,List 2)↵
List→Mat(List 1,List 2)↵
Trn Mat Ans→Mat C↵
Mat A-Mat C→Mat A↵
ClrText↵
"ANGLE"?→E↵
[[cos E,-sin E][sin E,cos E]]→Mat B↵
Mat B×Mat A→Mat D↵
Mat D+Mat C→Mat D↵
If A=1↵
Then PlotOn Mat D[1,1],Mat D[2,1]↵
Else For 1→B To A-1↵
Mat D[1,B]→F↵
Mat D[2,B]→G↵
Mat D[1,B+1]→H↵
Mat D[2,B+1]→I↵
F-Line F,G,H,I↵
Next↵
If A>2↵
Then Mat D[1,1]→F↵
Mat D[2,1]→G↵
F-Line H,I,F,G↵
IfEnd↵
IfEnd↵
Text 1,1,"--END--"
```



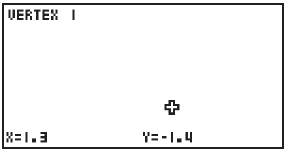
```
VERTEX NUMBER?
```

3 EXE



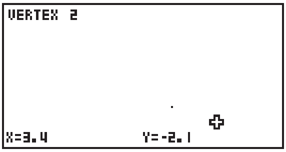
```
VERTEX 1
X=0              Y=0
```

▲ ▼ ◀ ▶



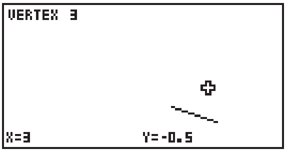
```
VERTEX 1
X=1.3            Y=-1.4
```

EXE EXE ▲ ▼ ◀ ▶



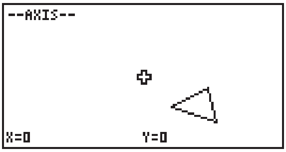
```
VERTEX 2
X=3.4            Y=-2.1
```

EXE EXE ▲ ▼ ◀ ▶



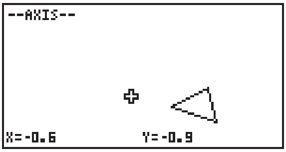
```
VERTEX 3
X=3              Y=-0.5
```

EXE EXE



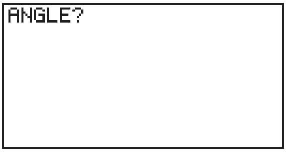
```
--AXIS--
X=0              Y=0
```

▲ ▼ ◀ ▶



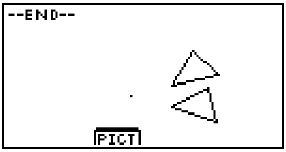
```
--AXIS--
X=-0.6           Y=-0.9
```

EXE EXE



```
ANGLE?
```

3 0 EXE



```
--END--
```

Program Name   Interior Angles and Surface Area of a Triangle

Description

This program calculates the interior angles and surface area of a triangle defined by input coordinates for angles A, B, and C.

Purpose

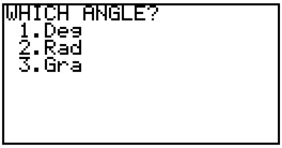
This program calculates the interior angles and surface area of a triangle defined by coordinates for angles A, B, and C.

Important!

Inputting the same coordinates for any two angles (A, B, C) causes an error.

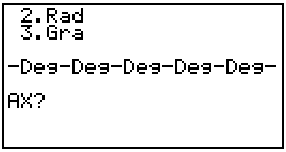
```
ClrText↵
"WHICH ANGLE?"↵
" 1.Deg"↵
" 2.Rad"↵
" 3.Gra"↵
Do↵
Getkey↵
LpWhile ((Ans=72) Or (Ans=62) Or (Ans=52))=0↵
If Ans=72↵
Then 1→θ↵
Deg↵
" "↵
"-Deg-Deg-Deg-Deg-Deg-"↵
IfEnd↵
If Ans=62↵
Then 2→θ↵
Rad↵
" "↵
"-Rad-Rad-Rad-Rad-Rad-"↵
IfEnd↵
If Ans=52↵
Then 3→θ↵
Gra↵
" "↵
"-Gra-Gra-Gra-Gra-Gra-"↵
IfEnd↵
"AX"?→A↵
"AY"?→B↵
"BX"?→C↵
"BY"?→D↵
"CX"?→E↵
"CY"?→F↵
A-C→G↵
B-D→H↵
C-E→I↵
D-F→J↵
E-A→K↵
F-B→L↵
-GI-HJ→M↵
-IK-JL→N↵
-KG-LH→O↵
√(G²+H²)→P↵
√(I²+J²)→Q↵
√(K²+L²)→R↵
M/PQ→S↵
N/QR→T↵
O/PR→U↵
cos⁻¹ S→V↵
cos⁻¹ T→W↵
cos⁻¹ U→X↵
PQ√(1-S²)→Y↵
ClrText↵
" <ABC ="↵
Locate 9,1,V↵
```

```
" <ACB ="↵
Locate 9,2,W↵
" <BAC ="↵
Locate 9,3,X↵
If θ=1↵
Then "             (Deg)"↵
IfEnd↵
If θ=2↵
Then "             (Rad)"↵
IfEnd↵
If θ=3↵
Then "             (Gra)"↵
IfEnd↵
" AREA ="↵
Locate 9,5,Y/2↵
" "↵
"END"
```



```
WHICH ANGLE?
 1.Deg
 2.Rad
 3.Gra
```

1



```
 2.Rad
 3.Gra

-Deg-Deg-Deg-Deg-Deg-

AX?
```

0 EXE 0 EXE

```

AX?
0
AY?
0
BX?
```

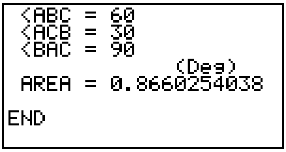
1 EXE 0 EXE

```
0
BX?
1
BY?
0
CX?
```

0 EXE √ 3

```
1
BY?
0
CX?
0
CY?
√3
```

EXE



```
 ∠ABC = 60
 ∠ACB = 30
 ∠BAC = 90
            (Deg)
 AREA = 0.8660254038

END
```

Chapter 9

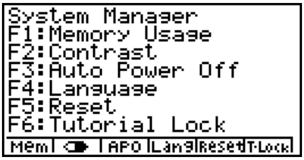
System Settings Menu

Use the system settings menu to view system information and make system settings. The system settings menu lets you do the following.

- View memory usage information
- Make contrast settings
- Make Auto Power Off settings
- Specify the system language
- Reset the calculator
- Tutorial Lock (ALGEBRA FX 2.0 PLUS only)

9-1 Using the System Settings Menu

From the Main Menu, enter the **SYSTEM** Mode and display the following menu items.



System Manager
F1:Memory Usage
F2:Contrast
F3:Auto Power Off
F4:Language
F5:Reset
F6:Tutorial Lock

- F1 (Mem) ... {display current memory status and delete data stored in memory}
- F2 (◁■) ... {display contrast adjustment}
- F3 (APO) ... {Auto Power Off time setting}
- F4 (Lang) ... {system language}
- F5 (Reset) ... {system reset operations}
- F6 (T-Lock) ... {Tutorial Lock}

- The T-Lock menu does not appear on the FX 1.0 PLUS.

9-2 Memory Operations

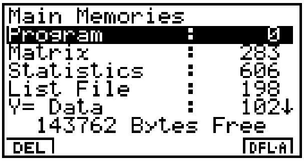
Use the Mem (Memory Usage) item to view current memory status and to delete certain data stored in memory.

While the initial System Settings Mode screen is displayed, press F1(Mem) to display the Memory Usage screen.

```
Memory Usage
F1:Main Memories
F2:Storage Memories
```

- F1(Main) ... {display the Main Memories screen}
- F2(Strg) ... {display the Storage Memories screen.}

Pressing F1(Main) displays data currently assigned to Main Memories.



```
Main Memories
Program       :     0
Matrix        :   283
Statistics    :   606
List File     :   198
Y= Data       :   102↓
  143762 Bytes Free
```

• To delete data

1. Use the ▲ and ▼ cursor keys to move the highlighting to the memory item whose data you want to delete.
2. Depending on the screen that is on your display, press the function key assigned to the DEL function.
   - From the Main Memories screen, press F1(DEL).*[1]
   - From the Storage Memories screen, press F6(DEL).
3. If you selected List File, Graph Memory, V-Win Memory, Picture or H-Copy Memory in step 1, a menu appears so you can select which data you want to delete.

   Input a number to specify the data and then press EXE.
4. In response to the confirmation message that appears, press EXE(Yes) to delete the data you specified, or ESC(No) to cancel.

Pressing ESC or SHIFT ESC(QUIT) returns to the initial System Settings Mode screen.

[1] Pressing F6(DEL • A) deletes all the data in the currently selected memory item.

Performing the procedure to delete add-in applications clears all currently installed add-ins. You cannot delete add-ins individually.

• To view memory usage information

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.

Main Memories

Data Type	Meaning
Program	Program data
Matrix	Matrix memory data
Statistics	Statistical calculations and graphs
List File	List data
Y=Data	Graph functions
Draw Memory	Graph drawing conditions (View Window, enlargement/reduction factor)
Graph Memory	Graph memory data
V-Win Memory	View Window memory data
Picture	Picture memory data
Table	Function Table & Graph data
Dynamic Graph	Dynamic Graph data
Recursion	Recursion Table & Graph data
Equation	Equation calculation data
Algebra	Algebra variable data (ALGEBRA FX 2.0 PLUS only)
Financial	Financial data
Diff Eq	Differential equation and graphing conditions
E-Con	E-CON setup memory, custom probe list
Alpha Memory	Alpha memory data
Function Mem	Function memory data
H-Copy Memory	Screen shot transfer memory
System	System Variable data
Others	Other data

Storage Memories[*1]

Data Type	Meaning
ADD-IN APP.	Add-in applications
[B]~	Backup data

Pressing F1 (Ver) displays the application names and versions of all currently installed add-ins.

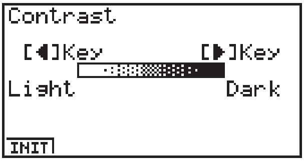
[*1] Any item that does not contain any data does not appear on the screen.

9-3 System Settings

■ Contrast Adjustment

Use the ◁■ (Contrast) item to adjust display contrast.

While the initial System Settings Mode screen is displayed, press F2(◁■) to display the Contrast Adjustment screen.



```
Contrast
 [◀]Key            [▶]Key
Light              Dark

INIT
```

- The ▶ cursor key makes display contrast darker.
- The ◀ cursor key makes display contrast lighter.
- F1(INIT) returns display contrast to its initial default.

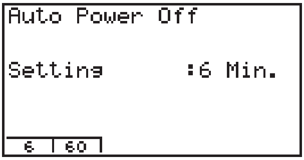
Pressing ESC or SHIFT ESC(QUIT) returns to the initial System Settings Mode screen.

You can adjust contrast while any screen besides the Main Menu is on the display by pressing SHIFT and then ▶ or ◀. To exit contrast adjustment, press SHIFT again.

■ APO Settings

You can specify either six minutes or 60 minutes as the Auto Power Off trigger time. The initial default setting is six minutes.

While the initial System Settings Mode screen is displayed, press F3(APO) to display the APO Setting screen.



```
Auto Power Off

Setting      :6 Min.

 6 | 60
```

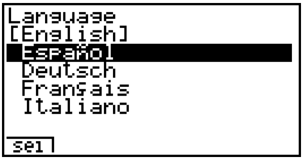
- F1(6) ... 6 minutes
- F2(60) ... 60 minutes

Pressing ESC or SHIFT ESC(QUIT) returns to the initial System Settings Mode screen.

System Language Setting

Use Lang to specify the display language for built-in applications. You can also use add-ins to install various other languages.

1. From the initial System Setting Mode screen, press F4 (Lang) to display the system language setting screen.



Language
[English]
 Español
 Deutsch
 Français
 Italiano

2. Use the ▲ and ▼ cursor keys to select the language you want, and then press F1 (Sel).
3. The pop up window appears using the language you selected. Check the contents and then press ESC.

Press ESC or SHIFT ESC (QUIT) to return to the initial System Setting Mode screen.

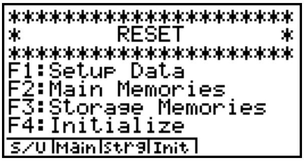
Installing a language with an add-in causes the installed language to be selected as the system language automatically.

English display only is supported for the following functions.
- Differential equations
- E-CON

This means that all displays are in English, even if another display language is selected.

9-4 Reset

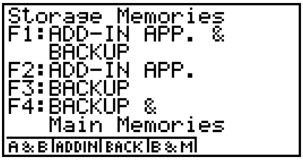
1. While the initial System Settings Mode screen is displayed, press F5 (Reset) to display the Reset Menu screen.



```
*********************
*       RESET       *
*********************
F1:Setup Data
F2:Main Memories
F3:Storage Memories
F4:Initialize
S/U |Main|Strg|Init|
```

   - F1 (S/U) ... {set up initialization}
   - F2 (Main) ... {main memory data clear}
   - F4 (Init) ... {all memory clear}

   Pressing F3 (Strg) on the above screen displays the Storage Memories screen shown below.



```
Storage Memories
F1:ADD-IN APP. &
   BACKUP
F2:ADD-IN APP.
F3:BACKUP
F4:BACKUP &
   Main Memories
A&B|ADDIN|BACK|B&M|
```

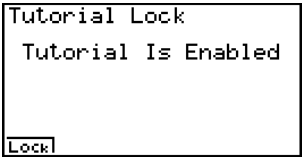
   - F1 (A&B) ... {Add-in application and backup data clear}
   - F2 (ADDIN) ... {Add-in application clear}
   - F3 (BACK) ... {Backup data clear}
   - F4 (B&M) ... {Backup data and Main Memories data clear}

2. Press the function key that corresponds to the reset operation you want to perform.
3. In response to the confirmation message that appears, press EXE (Yes) to perform the reset operation you specified, or ESC (No) to cancel.
4. A message appears to let you know when the reset operation is complete.
   Press MENU to return to the Main Menu.

9-5 Tutorial Lock (ALGEBRA FX 2.0 PLUS only)

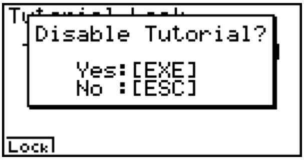
You can temporarily disable the Tutorial Mode (for 180 minutes).

1. From the initial System Setting Mode screen, press F6 (T-Lock) to display the Tutorial Lock screen.



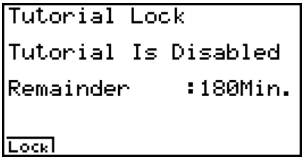
```
Tutorial Lock
 Tutorial Is Enabled



Lock
```

2. Pressing F1 (Lock) displays the pop-up menu.



```
Disable Tutorial?

   Yes:[EXE]
   No :[ESC]

Lock
```

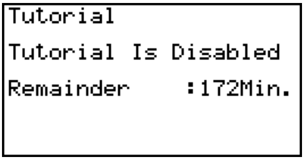
3. Pressing EXE (Yes) locks the Tutorial Mode so it cannot be used for 180 minutes.



```
Tutorial Lock
Tutorial Is Disabled
Remainder    :180Min.

Lock
```

Pressing ESC or SHIFT ESC (QUIT) returns to the initial System Settings Mode screen.

Attempting to enter the Tutorial Mode while Tutorial Lock is enabled displays a screen that shows the remaining Tutorial Lock time.



```
Tutorial
Tutorial Is Disabled
Remainder    :172Min.
```

Press ESC to return to the Main Menu.

Chapter 10

Data Communications

This chapter tells you everything you need to know to transfer programs between two CASIO Power Graphic calculators connected using the cable that is equipped as a standard accessory.
You can also use the cable to connect the calculator to a CASIO Label Printer to print screen data.

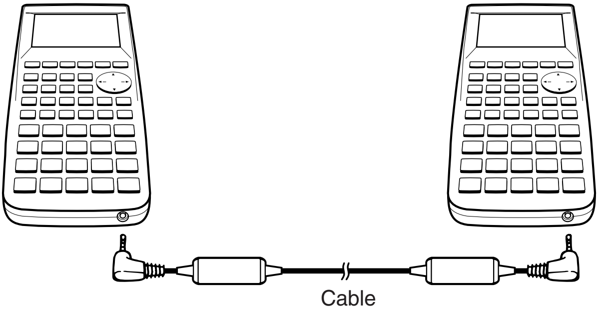
To transfer data between a calculator and a personal computer, you need to purchase the separately available CASIO FA-123 Connection Kit.

10-1 Connecting Two Units

The following procedure describes how to connect two units with the connecting cable that comes equipped as a standard accessory.

• 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.
3. Connect the two units using the cable.



Models that are supported for this configuration are shown below.

ALGEBRA FX 2.0/FX 2.0 PLUS
FX 1.0/FX 1.0 PLUS

Be sure you keep the connector covers in a safe place so you can replace them after you finish your data communications.

Keep the connectors covered when you are not using them.

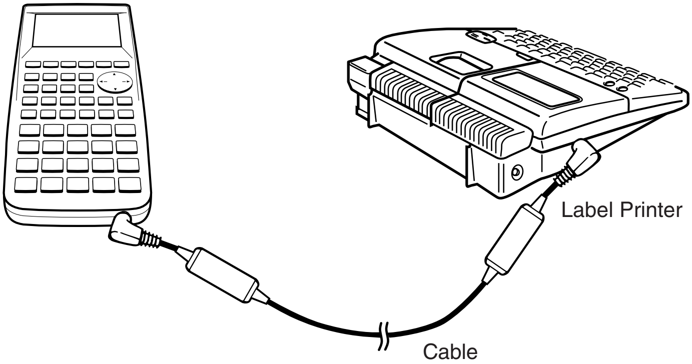
10-2 Connecting the Unit with a CASIO Label Printer

After you connect the unit to a CASIO Label Printer with cable, you can use the Label Printer to print screen shot data from the unit (see 10-6 Sending a Screen Shot). See the user's guide that comes with your Label Printer for details on how to perform this operation.

- The operation described above can be performed using the following Label Printer models: KL-2000, KL-2700, KL-8200, KL-8700 (as of February 1999).

•To connect the unit to a Label Printer

1. Check to make sure that the power of the unit and the Label Printer is off.
2. Connect the cable to the Label Printer.
3. Remove the cover from the connector of the unit.
4. Connect the other end of the cable to the unit.
5. Turn on the power of the unit, followed by the Label Printer.



- After you finish data communications, turn off power in the sequence: the unit first, and then the Label Printer. Finally, disconnect the equipment.

Be sure you keep the connector cover in a safe place so you can replace it after you finish your data communications.

10-3 Connecting the Unit to a Personal Computer

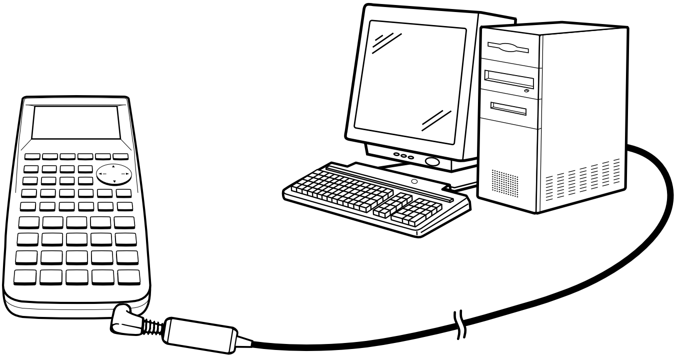
To transfer data and screen shots between the unit and a personal computer, you must connect them through a separately available CASIO FA-123 Connection Kit.

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-123.

Some types of data may not be able to be exchanged with a personal computer.

• To connect the unit to 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-123 Connection Kit.
3. Remove the cover from the connector of the unit.
4. Connect the unit to the FA-123 Connection Kit.
5. Turn on the power of the unit, followed by the personal computer.



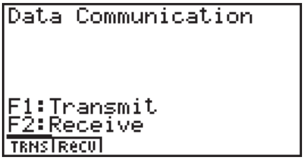
- After you finish data communications, turn off power in the sequence: the unit first, and then the personal computer. Finally, disconnect the equipment.

The ALGEBRA calculator also supports to PC transfer of programs created with a CASIO CFX-9850 Series calculator.

Be sure you keep the connector cover in a safe place so you can replace it after you finish your data communications.

10-4 Performing a Data Communication Operation

From the Main Menu, enter the LINK Mode. The following data communication main menu appears on the display.


```
Data Communication



F1:Transmit
F2:Receive
TRNS RECV
```

- {**TRNS**}/{**Recv**} ... menu of {send settings}/{receive settings}

Communication parameters are fixed at the following settings.

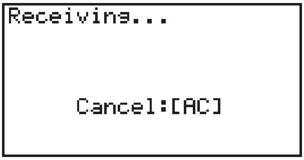
- Speed (BPS): 38.4 kbps (sending a data)
  9,600bps (sending a screen shot)
- Parity (PARITY): NONE

Performing a Data Transfer Operation

Connect the two units and then perform the following procedures.

Receiving unit

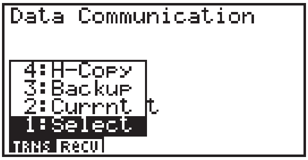
To set up the calculator to receive data, press F2(Recv) while the data communication main menu is displayed.


```
Receiving...



     Cancel:[AC]
```

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(TRNS) while the data communication main menu is displayed.

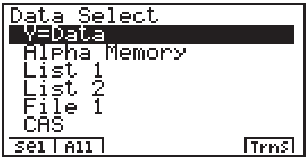


Press the number key that corresponds to the type of data you want to send.

- {**Select**} ... {selects data items and sends them}
- {**Currnt**} ... {selects data items from among previously selected data items and sends them}
- {**Backup**} ... {sends all memory contents, including mode settings}
- {**H-Copy**} ... {selects H-Copy screen shot data and sends it}

• To send selected data items

Press 1(Select) or 2(Currnt) to display a data item selection screen.



- {**Sel**} ... {selects data item where cursor is located}
- {**All**} ... {selects all data}
- {**Trns**} ... {sends selected data items}

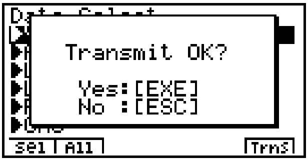
Use the ▲ and ▼ cursor keys to move the cursor to the data item you want to select and press F1(Sel) to select it. Currently selected data items are marked with "▶". Pressing F6 (Trns) sends all the selected data items.

- 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.

•To execute a send operation

After selecting the data items to send, press F6(Trns). A message appears to confirm that you want to execute the send operation.

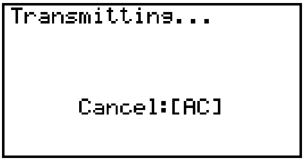


Transmit OK?

Yes:[EXE]
No :[ESC]

- EXE(Yes) ... sends data
- ESC(No) ... returns to data selection screen

Press EXE(Yes) to send the data.



Transmitting...

Cancel:[AC]

- 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

Complete!
Press:[ESC]

Receiving Unit

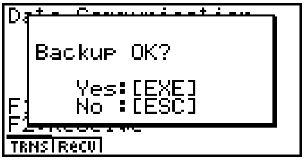
Complete!
Press:[ESC]

Press ESC 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 transmit data type selection menu is on the screen, press 3 (Backup), to display the screen shown below.


Backup OK?
Yes:[EXE]
No :[ESC]

Press EXE (Yes) to start the send operation.

The following shows what the displays of the sending and receiving units look like after the data communication operation is complete.

Sending Unit


Complete!
Press:[ESC]

Receiving Unit


Complete!
Press:[ESC]

Press ESC 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.

10-5 Data Communications Precautions

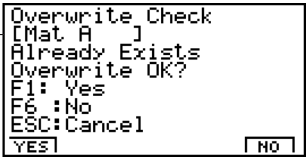
The following are the types of data items that can be sent.

Data Item	Contents	Overwrite Check[*1]	Password Check[*2]
Program names	Program contents (All programs are listed.)	Yes	Yes
Mat *n*	Matrix memory (A to Z) contents	Yes	
List *n*	List memory (1 to 20) contents	Yes	
File *n*	List file memory (1 to 6) contents	Yes	
Y=Data	Graph expressions, graph write/ non-write status, V-Window contents, zoom factors	No	
G-Mem *n*	Graph memory (1 to 20) contents	Yes	
V-Win *n*	V-Window memory contents	No	
Picture *n*	Picture (graph) memory (1 to 20) data	No	
DynaMem	Dynamic Graph functions	Yes	
Equation	Equation calculation coefficient values	No	
Alpha Memory	Variable memory contents	No	
F-Mem *n*	Function memory contents	No	
CAS	CAS formula data contents (ALGEBRA FX 2.0 PLUS only)	No	
Algebra	Algebra data contents (ALGEBRA FX 2.0 PLUS only)	No	
DIFF Equation	Differencial Equation data	No	
E-CON Data	E-CON data	No	
Add-in application names	Add-in application data (All add-in applications are listed.)	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.

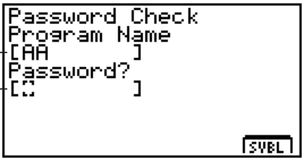
Data item name



```
Overwrite Check
[Mat A    ]
Already Exists
Overwrite OK?
F1: Yes
F6 :No
ESC: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.


Password Check
Program Name
[AA]
Password?
[ ]

Name of password protected file

Password input field

After inputting the password, press EXE.

Note the following precautions whenever you perform data communications.

- An error occurs whenever you try to send data to a receiving unit that is not yet standing by to receive data. When this happens, press ESC to clear the error and try again, after setting up the receiving unit to receive data.
- An error occurs whenever the receiving unit does not receive any data approximately six minutes after it is set up to receive data. When this happens, press ESC to clear the error.
- An error occurs during data communications if the cable becomes disconnected, if the parameters of the two units do not match, or if any other communications problem occurs. When this happens, press ESC to clear the error, then correct the problem before trying data communications again. If data communications are interrupted by the ESC key operation or an error, any data successfully received up to the interruption will be in the memory of the receiving unit.
- An error occurs if the receiving unit memory becomes full during data communications. When this happens, press ESC to clear the error and delete unneeded data from the receiving unit to make room for the new data, and then try again.
- The E-CON item contains the following data.
  1. Current Setup Data
  2. Setup Memory Data
  3. Custom Probe Memory Data

  The corresponding data is overwritten on the receiver. Setup Memory data and Custom Probe Memory data overwrites the data for the same memory number on the receiver. If you want to keep data from being overwritten on the receiver, change its memory number.

10-6 Sending a Screen Shot

Use the following procedures to send a hardcopy of the screen directly to a connected personal computer (or CASIO Label Printer) or to save a screen shot in memory to send later. Screen shots can also be sent to a CASIO Label Printer.

Use the LINK Mode set up (CTRL F3(SET UP)) to specify whether you want to send the screen shot now or save it in memory.

- **H-Copy**
  - {**Dirct**}/{**Mem**} .... {direct send}/{save}

• To send a screen shot directly to a connected computer (or CASIO Label Printer) (Direct)

1. Connect the unit to the computer (or CASIO Label Printer).

   On the computer (or CASIO Label Printer), perform the procedures required to set it up to receive data.

2. Display the screen you want to send.

3. Press CTRL F6(H-COPY).

• To save a screen shot in memory (Memory)

1. Display the screen you want to save.

2. Press CTRL F6(H-COPY).
   - You can store up to 20 screen shots in memory. Saved screen shots are automatically assigned file names from Hcopy1 to Hcopy20.

You cannot send the following types of screens to a computer or a Label Printer.
- 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.

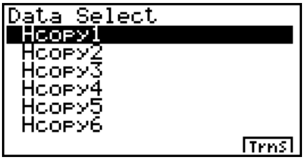
The flashing cursor is not included in the screen image that is sent from the unit.

You cannot use 6mm wide tape to print a screen shot of a graph.

• To send a saved screen shot to a computer or CASIO Label Printer

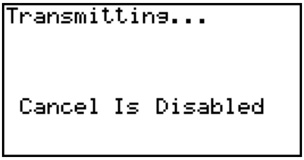
1. Connect the unit to the computer (or CASIO Label Printer). On the computer (or CASIO Label Printer), perform the procedures required to set it up to receive data.

2. In the LINK Mode, press F1(TRNS) 4(H-Copy) to display the list of screen shots in memory.



```
Data Select
 Hcopy1
 Hcopy2
 Hcopy3
 Hcopy4
 Hcopy5
 Hcopy6
```

3. Use the ▲ and ▼ cursor keys to highlight the name of the screen shot you want to send, and then press F6(Trns).



```
Transmitting...


 Cancel Is Disabled
```

10-7 Add-ins

Add-in capabilities let you install separately available applications and other software to tailor the calculator to suit your particular needs.
Add-ins are installed from a computer using the data communication described on page 10-4-1.
The following are the types of software that can be installed as add-ins.

• Add-in Application

After you install an application, its icon appears in the Main Menu, and you can run it just as you would a built-in application.

• Built-in Application Upgrades

These are upgrades for the applications that are pre-programmed in the calculator's ROM.

• On-screen Message Language Data

This data is required to display on-screen messages in other languages. Installing this data causes all on-screen messages to appear in the corresponding language.

10-8 MEMORY Mode

This calculator has two separate memory areas: a “current area” and a “storage area.” The current area is a work area where you can perform input data, perform calculations and run programs. Data in the current area is relatively safe, but it can be deleted when batteries go dead or when you perform a full reset.

The storage area uses “flash memory,” so data is safe even when power is interrupted. Normally, you would use the storage area for data you need to store securely for long periods and load it into the current area only when you need it.

Use the MEMORY Mode to transfer data between the current area and storage area, and to perform other memory management operations.

From the Main Menu, select the **MEMORY** icon to enter the MEMORY Mode and display its initial screen.

Memory Manager

F1:Program Files
F2:Backup
F3:Optimization

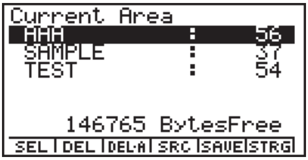
- {**PROG**} ...... {program file save, load, delete, search}
- {**BACK**} ...... {current area data backup and restore}
- {**OPT**} .... {optimization of the storage area}

■ Storing and Loading Program Files

Use the following procedures to store a current area program file into the storage area, and to load a file from the storage area into the current area.

• To store a program file into the storage area

1. On the initial MEMORY Mode screen press F1(PROG).
   - This displays a list of program files that are in the current area.*[1]



```
Current Area
 AAA            :     56
 SAMPLE         :     37
 TEST           :     54

     146765 BytesFree
```

2. Select the program file you want to store.
   - Use the cursor ▲ and ▼ keys to highlight the name of the program file you want to store, and then press F1(SEL).

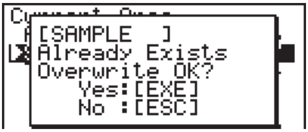
3. Press F5(SAVE).

The message “Complete!” appears when the store operation is finished.

Press ESC to return to the screen displayed in step 1.

A “Memory ERROR” occurs and the store operation is terminated if the storage area becomes full.

The following message appears if there is already a program file in the storage area with the same name as the program file you are trying to save.

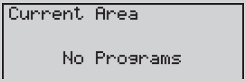


```
[SAMPLE   ]
Already Exists
Overwrite OK?
   Yes:[EXE]
   No :[ESC]
```

Press EXE(Yes) to save the new program file, or ESC(No) to cancel the save operation.

---

*[1] This screen appears as shown to the right if there are no program files in the current area when you start the save operation.

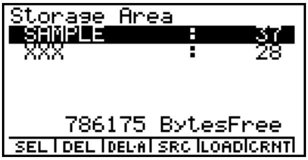


```
Current Area

     No Programs
```

• To load a program file from the storage area

1. On the initial MEMORY Mode screen press F1(PROG).

2. Press F6(STRG).
   - This displays a list of program files that are in the storage area. *[1]



```
Storage Area
 SAMPLE          :      37
 XXX             :      28

      786175 BytesFree
```

3. Select the program file you want to load.
   - Use the cursor ⏶ and ⏷ keys to highlight the name of the program file you want to load, and then press F1(SEL).

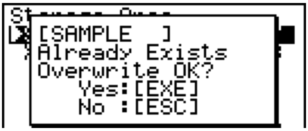
4. Press F5(LOAD).

The message "Complete!" appears when the load operation is finished.

Press ESC to return to the screen displayed in step 1.

A "Memory ERROR" occurs and the load operation is terminated if the current area becomes full.

The following message appears if there is already a program file in the current area with the same name as the program file you are trying to load.

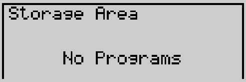


```
[SAMPLE   ]
Already Exists
Overwrite OK?
   Yes:[EXE]
   No :[ESC]
```

Press EXE(Yes) to load the new program file, or ESC(No) to cancel the load operation.

---

*[1] The screen appears as shown below if there are no program files in the storage area when you start the load operation.



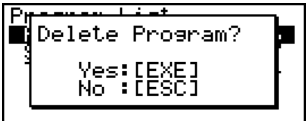
```
Storage Area

      No Programs
```

Deleting Program Files

Use the following procedures to delete individual files or all files in the current area or storage areas.

• To delete a current area program file

1. On the initial MEMORY Mode screen press F1 (PROG).
   - This displays a list of program files that are in the current area.
2. Use the cursor ▲ and ▼ keys to highlight the name of the program file you want to delete, and then press F2 (DEL).



Delete Program?

Yes:[EXE]
No :[ESC]

- Press EXE (Yes) to delete the program file.
- Press ESC (No) to cancel the delete operation.

• To delete a storage area program file

1. On the initial MEMORY Mode screen press F1 (PROG).
2. Press F6 (STRG).
   - This displays a list of program files that are in the storage area.
3. Use the cursor ▲ and ▼ keys to highlight the name of the program file you want to delete, and then press F2 (DEL).

- Press EXE (Yes) to delete the program file.
- Press ESC (No) to cancel the delete operation.

• To delete all the program files in the current area

1. On the initial MEMORY Mode screen press F1 (PROG).
   - This displays a list of program files that are in the current area.
2. Press F3 (DEL•A).

Delete
All Programs?
Yes:[EXE]
No :[ESC]

- Press EXE (Yes) to delete all the program files in the current area.
- Press ESC (No) to cancel the delete operation.

• To delete all the program files in the storage area

1. On the initial MEMORY Mode screen press F1(PROG).

2. Press F6(STRG).
   - This displays a list of program files that are in the storage area.

3. Press F3(DEL•A).

- Press EXE(Yes) to delete all the program files in the storage area.
- Press ESC(No) to cancel the delete operation.

■ Searching for a Program File

Use the following procedures to search for a specific program file in the current area or in the storage area.

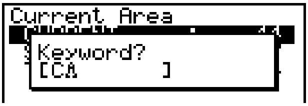
• To search for a program file in the current area *[1]

● ● ● ● ●

Example **To search for all program files in the current area whose names begin with the letter "C"**

1. On the initial MEMORY Mode screen press F1(PROG).
   - This displays a list of program files that are in the current area.

2. Press F4(SRC).
   - Input the letter "C" for the keyword.



```
Current Area
Keyword?
[CA        ]
```

- The first program file name that begins with the letter "C" appears highlighted on display.

```
Current Area
 CURRENT      :    44
 SAMPLE       :    37
 TEST         :    54
```

[1] You can input up to eight characters for the keyword.

The message "Not Found" appears if there are no program file names that match your keyword.

• To search for a program file in the storage area

● ● ● ● ●

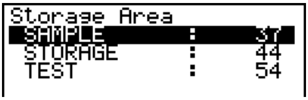
Example **To search for all program files in the storage area whose names begin with the letter "S"**

1. On the initial MEMORY Mode screen press F1(PROG).

2. Press F6(STRG).
   - This displays a list of program files that are in the storage area.

3. Press F4(SRC).
   - Input the letter "S" for the keyword.

- The first program file name that begins with the letter "S" appears highlighted on display.



```
Storage Area
 SAMPLE      :    37
 STORAGE     :    44
 TEST        :    54
```

Press ▼ or F1(SRC) to highlight the next file name that matches your keyword.

Press ▲ to highlight the previous file name that matches your keyword.

The message "Not Found" appears if there are no program file names that match your keyword.

Press ESC to exit the search.

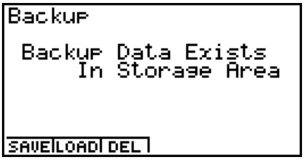
■ Backing Up Current Area Data

You can back up all the data in the current area and store it in the storage area. Later you can restore the backed up data to the current area when necessary.

• To back up current area data

1. On the initial MEMORY Mode screen press F2(BACK).
   - Screen A appears if there is already backup data in the storage area. Screen B appears if there is no backup data in the storage area.

Screen A


Backup

Backup Data Exists
In Storage Area

Screen B


Backup

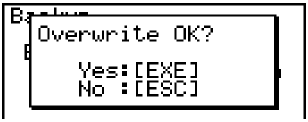
No Backup Data
In Storage Area

2. Press F1(SAVE) to backup the data.

The message “Complete!” appears when the backup operation is finished.

Press ESC to return to the screen displayed in step 1.

The following message appears if there is already backup data in the storage area.


Overwrite OK?

Yes:[EXE]
No :[ESC]

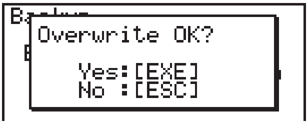
Press EXE(Yes) to back up the data, or ESC(No) to cancel the backup operation.

A “Memory ERROR” occurs when there is not enough space available in the storage area to complete the backup operation.

• To restore backup data to the current area

1. On the initial MEMORY Mode screen press F2(BACK).
   - On the screen that appears, you can confirm whether or not there is backup data in the storage area.

2. Press F2(LOAD).
   - A message appears to confirm whether or not you really want to restore the backed up data.



Overwrite OK?
Yes:[EXE]
No :[ESC]

Press EXE(Yes) to restore the data and delete any data currently in the area.

Press ESC(No) to cancel the data backup operation.

The message “Complete!” appears when the restore operation is finished.

Press ESC to return to the screen displayed in step 1.

• To delete backup data from the storage area

1. On the initial MEMORY Mode screen press F2(BACK).
   - On the screen that appears, you can confirm whether or not there is backup data in the storage area.

2. Press F3(DEL).
   - A message appears to confirm whether or not you really want to delete the backed up data.

Delete
Backup Data?
Yes:[EXE]
No :[ESC]

Press EXE(Yes) to delete the backed up data from the storage area.

Press ESC(No) to cancel the backup data delete operation.

The message “Complete!” appears when the delete operation is complete.

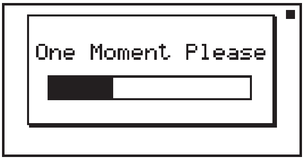
Press ESC to return to the screen displayed in step 1, which now contains the message “No Backup Data.”

■ Optimizing the Storage Area

Storage area memory can become fragmented after many store and load operations. Fragmentation can cause blocks of memory to become unavailable for data storage. Because of this, you should periodically perform the storage area optimization procedure, which rearranges the data in the storage area and makes memory usage more economical.

• To optimize the storage area

On the initial MEMORY Mode screen press F3 (OPT) to start storage area optimization.



One Moment Please

The message “Complete!” appears when the optimize operation is complete.

Press ESC to return to the initial MEMORY Mode screen.

Appendix

1 Error Message Table

Message	Meaning	Countermeasure
Syntax ERROR	• Illegal syntax • Attempt to input an illegal command	• Press ESC to display the error and make necessary corrections.
Ma ERROR	• Calculation result exceeds the display range. • Calculation is outside the input range of a function. • Mathematical error (division by zero, etc.) • Sufficient precision could not be obtained for Σ calculation, differential calculation, etc. • Solution could not be obtained for equation calculation, etc.	• Check input values and make corrections to ensure that values are within allowable limits.
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.
Nesting 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.
Stack 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.

Message	Meaning	Countermeasure
Memory ERROR	• Operation or memory storage operation exceeds remaining memory capacity.	• 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.
Argument ERROR	• Incorrect argument specification for a command that requires an argument.	• Correct the argument.
Dimension ERROR	• Illegal dimension or list used during matrix calculations.	• Check the matrix or list dimension.
Range ERROR	① Input of an improper V-Window value. ② V-Window range settings exceeded when a graph is redrawn. ③ Input of an improper value on the range screen and use of that value for execution.	① Change the V-Window value so it is within range. ② Redraw using the proper settings. ③ Input a proper range value.
Condition ERROR	• Execution of a calculation or function before all conditions required for execution are met.	• Check the conditions and make any necessary corrections.
Non-Real ERROR	① Calculation that produces a complex number when Real is specified for the Complex Mode setting on the SET UP screen, even though the argument is a real number. ② Calculation that produces a complex number when Real is specified for the Answer Type setting on the SET UP screen, even though the argument is a real number. (ALGEBRA FX 2.0 PLUS only)	① Change the Complex Mode setting to something other than Real. ② Change the Answer Type setting to something other than Real. (ALGEBRA FX 2.0 PLUS only)

Message	Meaning	Countermeasure
Complex Number In List	• List containing complex number used in a calculation or operation for which complex number data is invalid.	• Change all data in the list to real numbers.
Complex Number In Matrix	• Matrix containing complex number used in a calculation or operation for which complex number data is invalid.	• Change all data in the matrix to real numbers.
Can't Solve! Adjust Initial Value Or Bounds. Then Try Again	• Solve could not obtain a solution within the specified range.	• Change the specified range. • Correct the input expression.
No Variable	• No variable specified within a graph function being used for Dynamic Graph. • No variable within a Solve equation.	• Specify a variable for the graph function.
Iteration ERROR	① No convergence of Solve solutions. ② No integration or differential calculation solution that satisfies operation ending condition (*tol* value).	① Change the initial estimated value to one that is nearer to the solution. ② Increase the *tol* value to reduce precision.
Com ERROR	• Problem with cable connection or parameter setting during program data communications.	• Check the cable connection.
Transmit ERROR	• Problem with cable connection or parameter setting during data communications.	• Check the cable connection.
Receive ERROR	• Problem with cable connection or parameter setting during data communications.	• Check the cable connection.
Memory Full	• Memory of receiving unit became full during program data communications.	• Delete some data stored in the receiving unit and try again.

Message	Meaning	Countermeasure
Download ERROR	• Data communication cable disconnect during add-in installation, or incorrect data transfer conditions.	• Press EXE and try again. • Press ESC and try again.
Model Mismatch	• Attempt to perform back up between two different models.	• Use two identical models.
Overflow ERROR *	• Overflow of the calculation range in the Algebre Mode.	• Correct the input expression.
Domain ERROR *	• Overflow of the input element range in the Algebre Mode.	• Correct the input expression.

* ALGEBRA FX 2.0 PLUS only

2 Input Ranges

Function	Input range for real number solutions	Internal digits	Precision	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, precision 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 * Complex numbers can be used as arguments.
$\sin^{-1}x$ $\cos^{-1}x$	$\lvert x\rvert \leqq 1$	"	"	* Complex numbers can be used as arguments.
$\tan^{-1}x$	$\lvert x\rvert < 1 \times 10^{100}$			
sinh$x$ cosh$x$	$\lvert x\rvert \leqq 230.2585092$	"	"	* Complex numbers can be used as arguments.
tanh$x$	$\lvert x\rvert < 1 \times 10^{100}$			
$\sinh^{-1}x$	$\lvert x\rvert < 5 \times 10^{99}$	"	"	* Complex numbers can be used as arguments.
$\cosh^{-1}x$	$1 \leqq x < 5 \times 10^{99}$			
$\tanh^{-1}x$	$\lvert x\rvert < 1$			
log$x$ ln$x$	$1 \times 10^{-99} \leqq x < 1 \times 10^{100}$	"	"	* Complex numbers can be used as arguments.
10^x	$-1 \times 10^{100} < x < 100$	"	"	* Complex numbers can be used as arguments.
e^x	$-1 \times 10^{100} < x \leqq 230.2585092$			
$\sqrt{x}$	$0 \leqq x < 1 \times 10^{100}$	"	"	* Complex numbers can be used as arguments.
x^2	$\lvert x\rvert < 1 \times 10^{50}$			
$1/x$	$\lvert x\rvert < 1 \times 10^{100}$, $x \neq 0$	"	"	* Complex numbers can be used as arguments.
$\sqrt[3]{x}$	$\lvert x\rvert < 1 \times 10^{100}$			
$x!$	$0 \leqq x \leqq 69$ (x is an integer)	"	"	
nPr nCr	Result $< 1 \times 10^{100}$ n, r (n and r are integers) $0 \leqq r \leqq n$, $n < 1 \times 10^{10}$	"	"	

Function	**Input range for real number solutions**	**Internal digits**	**Precision**	**Notes**
Pol (x, y)	$\sqrt{x^2 + y^2} < 1 \times 10^{100}$	15 digits	As a rule, precision is ±1 at the 10th digit.*	
Rec (r, θ)	$\lvert r \rvert < 1 \times 10^{100}$ (DEG) $\lvert \theta \rvert < 9 \times (10^9)°$ (RAD) $\lvert \theta \rvert < 5 \times 10^7 \pi$ rad (GRA) $\lvert \theta \rvert < 1 \times 10^{10}$grad	"	"	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: $\lvert x \rvert < 1 \times 10^7$			
$\wedge(x^y)$	$x > 0$: $-1 \times 10^{100} < y \log x < 100$ $x = 0 : y > 0$ $x < 0$: $y = n, \frac{1}{2n+1}$ (n is an integer or a fraction) However; $-1 \times 10^{100} < y \log \lvert x \rvert < 100$	"	"	* Complex numbers can be used as arguments.
$^x\sqrt{y}$	$y > 0 : x \neq 0$ $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ $y = 0 : x > 0$ $y < 0 : x = 2n + 1, \frac{1}{n}$ ($n \neq 0$, n is an integer or a fraction) However; $-1 \times 10^{100} < \frac{1}{x} \log \lvert y \rvert < 100$	"	"	* Complex numbers can be used as arguments.
a^{b}/c	Total of integer, numerator and denominator must be within 10 digits (includes division marks).	"	"	

---

* For a single calculation, calculation error is ±1 at the 10th digit. (In the case of exponential display, calculation error is ±1 at the last significant digit.) Errors are cumulative in the case of consecutive calculations, which can also cause them to become large. (This is also true of internal consecutive calculations that are performed in the case of $\wedge(x^y)$, $^x\sqrt{y}$, $x!$, $^3\sqrt{x}$, nPr, nCr, etc.)
In the vicinity of a function's singular point and point of inflection, errors are cumulative and may become large.

Function	**Input range**
Binary, octal, decimal, hexadecimal calculation	Values fall within following ranges after conversion: DEC: $-2147483648 \leqq x \leqq 2147483647$ BIN: $1000000000000000 \leqq x$ $\leqq 1111111111111111$ (negative) $0 \leqq x \leqq 0111111111111111$ (0, positive) OCT: $20000000000 \leqq x \leqq 37777777777$ (negative) $0 \leqq x \leqq 17777777777$ (0, positive) HEX: $80000000 \leqq x \leqq$ FFFFFFFF (negative) $0 \leqq x \leqq$ 7FFFFFFF (0, positive)

3 Specifications

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: $10^{-9} > |x|, |x| \geqq 10^{10}$

Program capacity: 144 kbytes (max.)

Power supply:
Main: Four AAA-size batteries (LR03 (AM4) or R03 (UM-4))
Back-up: One CR2032 lithium battery

Power consumption: 0.2 W

Approximate battery life
Main (ALGEBRA FX 2.0 PLUS):
LR03 (AM4): 230 hours (continuous display of main menu)
150 hours continuous operation (5 minutes calculation, 55 minutes display)
R03 (UM-4): 140 hours (continuous display of main menu)
90 hours continuous operation (5 minutes calculation, 55 minutes display)
Main (FX 1.0 PLUS):
LR03 (AM4): 200 hours (continuous display of main menu)
140 hours continuous operation (5 minutes calculation, 55 minutes display)
R03 (UM-4): 120 hours (continuous display of main menu)
80 hours continuous operation (5 minutes calculation, 55 minutes display)
Back-up: 2 years

Auto power off:

Power is automatically turned off approximately six minutes or 60 minutes after last operation.

Ambient temperature range: 0 °C to 40 °C

Dimensions: 19.5 mm (H) × 82 mm (W) × 178 mm (D)
$^{3}/_{4}$" (H) × 3 $^{1}/_{4}$" (W) × 6 $^{7}/_{8}$" (D)

Weight: Approx. 213 g (including batteries)

Data Communications

Method: Start-stop (asynchronous), half-duplex

Transmission speed (BPS): 38400 bits/second (normal)
9600 bits/second (H-Copy & Send/Receive)

Parity: None

Bit length: 8 bits

Stop bit:

Send: 3 bits
Receive: 2 bits
Includes parity (None) 1-bit

X ON/X OFF Control: None

4 Index

CAS, ALGEBRA, TUTOR Command Index

PRGM Command Index

5 Key Index

Key	Primary Function	Combined with CTRL	Combined with ALPHA
COPY F1	Selects 1st function menu item.	Performs copy operation.	
PASTE F2	Selects 2nd function menu item.	Performs paste operation.	
SET UP F3	Selects 3rd function menu item.	Shows the set up display.	
CAT/CAL F4	Selects 4th function menu item.	Shows the Catalog or opens the Calc Window.	
G ↔ T F5	Selects 5th function menu item.	Switches display between graph and text screens.	
H-COPY F6	Selects 6th function menu item.	Sends a shot of the current screen to a connected device.	
0	Enters number 0.	Toggles function menu display on and off.	

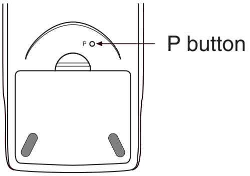
Key	Primary Function	Combined with SHIFT	Combined with ALPHA
SHIFT	Activates shift functions of other keys and function menus.		
CTRL	Activates functions marked above function keys.		
V-Window OPTN	Displays option menu.	Displays View Window parameter input screen.	
MENU	Returns to the Main Menu.		
A-LOCK ALPHA	Allows entry of alphanumeric characters shown in red.	Locks/Unlocks entry of alphanumeric characters.	
PRGM r VARS	Displays the variable data menu.	Displays program command menu.	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 ESC	Back steps to the previous screen without making any changes.	Returns directly to initial screen of the mode.	

Key	Primary Function	Combined with SHIFT	Combined with ALPHA
▲	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.		
▶	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.
$\sqrt{\ }$ H x^2	Press after entering value to calculate square.	Press before entering value to calculate square root.	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.

Key	Primary Function	Combined with SHIFT	Combined with ALPHA
O 9	Enters number 9.		Enters letter O.
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.
List U 1	Enters number 1.	Inputs List command.	Enters letter U.
Mat V 2	Enters number 2.	Inputs Mat command.	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.
i Z 0	Enters number 0.	Inputs imaginary number unit.	Enters letter Z.
= SPACE •	Enters decimal point.	Enters character =.	Enters a blank space.
π ” EXP	Enables entry of exponent.	Inputs value of pi. Enters pi symbol.	Enters double quotation mark.
Ans (−)	Enter before value to specify as negative.	Recalls most recent calculation result.	
↵ EXE	Displays result of calculation.	Inputs a new line.	

6 P Button (In case of hang up)

Pressing the P button resets the calculator to its initial defaults.



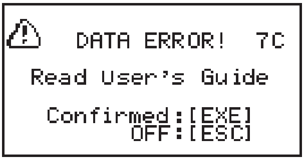
Warning!

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 P button operation.

- Pressing the P button while a calculation operation is being performed (while the calculator is performing a calculation internally) deletes all data in memory.
- You can also reset the calculator using front panel key operations (see 9-4 Reset). Use the P button to reset only while the front panel keys are disabled for some reason.

• DATA ERROR Message

A data error indicates that data in calculator memory is seriously corrupted. This can be due to exposure of the calculator to strong electrostatic charge, temperature extremes, high humidity, etc. A data error is indicated by appearance of the screen shown below.



```
⚠    DATA ERROR!   7C
  Read User's Guide
   Confirmed:[EXE]
         OFF:[ESC]
```

Press the EXE key to reset the calculator.

- The data error screen appears when you press the P button to reset the calculator or when you turn on calculator power.

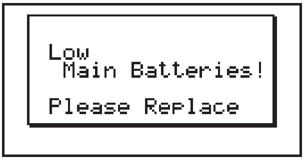
Warning!

Pressing EXE deletes all data in calculator memory.
If a data error occurs when you press EXE, it could mean that your calculator is malfunctioning. If the data error screen keeps appearing, press ESC to turn off power. Next, take the calculator to the retailer where you purchased it or to your local CASIO service provider.

7 Power Supply

This calculator 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 either of the following messages appears on the display, immediately turn off the calculator and replace main batteries or the back up battery as instructed.



```
Low
 Main Batteries!

Please Replace
```

```
Low
 Backup Battery!

Please Replace
```

If you try to continue using the calculator, it will automatically turn off in order to protect memory contents. You will not be able to turn power back on until you replace batteries.

Be sure to replace the main batteries at least once every two years, no matter how much you use the calculator during that time.

The batteries that come with this calculator discharge slightly during shipment and storage. Because of this, they may require replacement sooner than the normal expected battery life.

Warning!

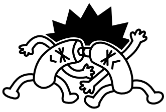
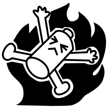
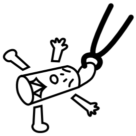
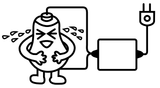
All memory contents will be deleted if you remove both the main power supply and the memory back up batteries at the same time. If you ever remove both batteries, correctly reload them and then perform the reset operation.

Replacing Batteries

Precautions:

Incorrectly using batteries can cause them to burst or leak, possibly damaging the interior of the calculator. 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 calculator for long periods.
- Never try to recharge the batteries supplied with the calculator.
- 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 calculator 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

* Before replacing the main power supply batteries, turn on the calculator and check to see if the “Low Backup Battery!” message appears on the display. If it does, replace the memory back up battery before replacing the main power supply batteries.

* Never remove the main power supply and the memory back up batteries from the calculator at the same time.

* Never turn on the calculator while the main power supply batteries are removed 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.

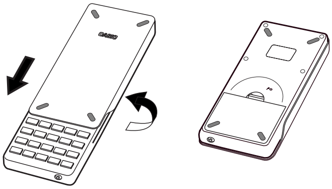
* Be sure to replace all four batteries with new ones.

1. Press [SHIFT] [AC/ON] (OFF) to turn off the calculator.

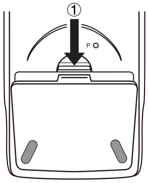
Warning!

* Be sure to turn the calculator 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 it over.

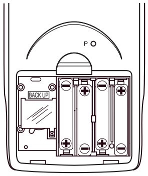


3. Remove the back cover from the calculator by pulling with your finger at the point marked ①.



4. Remove the four old batteries.

5. Load a new set of four batteries, making sure that their positive (+) and negative (–) ends are facing in the proper directions.



6. Replace the back cover.

7. Turn the calculator front side up and slide off its case. Next, press [AC/ON] to turn on power.

\# Power supplied by memory back up battery while the main power supply batteries are removed for replacement retains memory contents.

\# Do not leave the calculator without main power supply batteries loaded for long periods. Doing so can cause deletion of data stored in memory.

\# If the figures on the display appear too light and hard to see after you turn on power, adjust the tint.

• To replace the memory back up battery

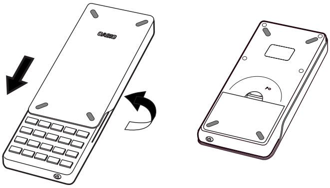
- * Before replacing the memory back up battery, check to make sure the main batteries are not dead.
- * Never remove the main power supply and the memory back up batteries from the calculator at the same time.
- * Be sure to replace the back up power supply battery at least once 2 years, regardless of how much you use the calculator during that time. Failure to do so can cause data in memory to be deleted.

1. Press SHIFT AC/ON (OFF) to turn off the calculator.

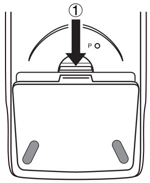
Warning!

* Be sure to turn the calculator off before replacing battery. Replacing battery 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 it over.

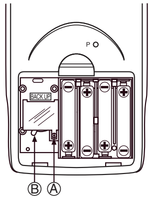


3. Remove the back cover from the calculator by pulling with your finger at the point marked ①.

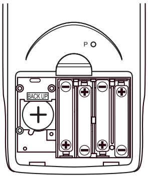


4. Remove screw Ⓐ on the back of the calculator, and remove the back up battery compartment cover.

5. Insert a thin, pointed non-metal object (such as a toothpick) into the hole maked Ⓑ and remove the old battery.



6. Wipe off the surfaces of a new battery with a soft, dry cloth. Load it into the calculator so that its positive (+) side is facing up.



7. Install the memory protection battery cover onto the calculator and secure it in place with the screw. Next, replace the back cover.

8. Turn the calculator front side up and slide off its case. Next, press AC/ON to turn on power.

About the Auto Power Off Function

Calculator power turns off automatically if you do not perform any operation within the Auto Power Off trigger time you specify. You can specify either six minutes or 60 minutes as the trigger time (see “APO Settings” on page 9-3-1). To restore power, press AC/ON.

ALGEBRA FX 2.0 PLUS
FX 1.0 PLUS

(Additional Functions)

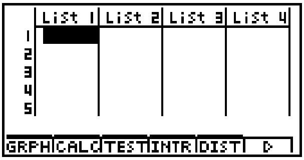
Chapter 1

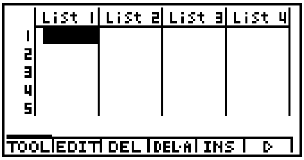
Advanced Statistics Application

1-1 Advanced Statistics (STAT)

•Function Menu

The following shows the function menus for the STAT Mode list input screen.





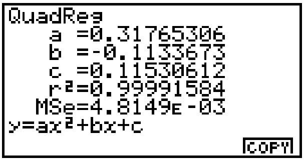
Pressing a function key that corresponds to the added item displays a menu that lets you select one of the functions listed below.

- F3 (TEST) ... Test (page1-2-1)
- F4 (INTR) ... Confidence interval (page1-3-1)
- F5 (DIST) ... Distribution (page1-4-1)

SORT and JUMP functions are located in the TOOL menu (F6 (▷) F1 (TOOL)).

•Calculation of the Coefficient of Determination (r^2) and MSE

You can use the STAT Mode to calculate the coefficient of determination (r^2) for quadratic regression, cubic regression, and quartic regression. The following types of MSE calculations are also available for each type of regression.



```
QuadReg
   a =0.31765306
   b =-0.1133673
   c =0.11530612
   r²=0.99991584
  MSe=4.8149E-03
y=ax²+bx+c
```

- Linear Regression ... $$MSE = \frac{1}{n-2}\sum_{i=1}^{n}(y_i - (ax_i + b))^2$$
- Quadratic Regression ... $$MSE = \frac{1}{n-3}\sum_{i=1}^{n}(y_i - (ax_i^2 + bx_i + c))^2$$
- Cubic Regression ... $$MSE = \frac{1}{n-4}\sum_{i=1}^{n}(y_i - (ax_i^3 + bx_i^2 + cx_i + d))^2$$
- Quartic Regression ... $$MSE = \frac{1}{n-5}\sum_{i=1}^{n}(y_i - (ax_i^4 + bx_i^3 + cx_i^2 + dx_i + e))^2$$

- Logarithmic Regression ... $MSE = \frac{1}{n-2}\sum_{i=1}^{n}(y_i - (a + b\ln x_i))^2$
- Exponential Repression ... $MSE = \frac{1}{n-2}\sum_{i=1}^{n}(\ln y_i - (\ln a + bx_i))^2$
- Power Regression ... $MSE = \frac{1}{n-2}\sum_{i=1}^{n}(\ln y_i - (\ln a + b\ln x_i))^2$
- Sin Regression ... $MSE = \frac{1}{n-2}\sum_{i=1}^{n}(y_i - (a\sin(bx_i + c) + d))^2$
- Logistic Regression ... $MSE = \frac{1}{n-2}\sum_{i=1}^{n}\left(y_i - \frac{C}{1 + ae^{-bx_i}}\right)^2$

•Estimated Value Calculation for Regression Graphs

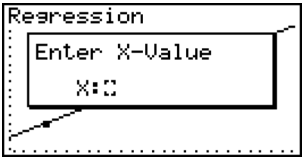
The STAT Mode also includes a Y-CAL function that uses regression to calculate the estimated y-value for a particular x-value after graphing a paired-variable statistical regression.

The following is the general procedure for using the Y-CAL function.

1. After drawing a regression graph, press F6(▷)F2(Y-CAL) to enter the graph selection mode, and then press EXE.

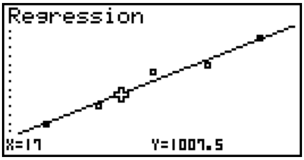
   If there are multiple graphs on the display, use ▲ and ▼ to select the graph you want, and then press EXE.

- This causes an x-value input dialog box to appear.



Enter X-Value
X:

2. Input the value you want for x and then press EXE.



X=17 Y=1007.5

- This causes the coordinates for x and y to appear at the bottom of the display, and moves the pointer to the corresponding point on the graph.

3. Pressing X,θ,T or a number key at this time causes the x-value input dialog box to reappear so you can perform another estimated value calculation if you want.

4. After you are finished, press ESC to clear the coordinate values and the pointer from the display.

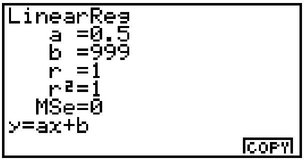
· The pointer does not appear if the calculated coordinates are not within the display range.

· The coordinates do not appear if [Off] is specified for the [Coord] item of the [SETUP] screen.

· The Y-CAL function can also be used with a graph drawn by using DefG feature.

•Regression Formula Copy Function from a Regression Calculation Result Screen

In addition to the normal regression formula copy function that lets you copy the regression calculation result screen after drawing a statistical graph (such as Scatter Plot), the STAT Mode also has a function that lets you copy the regression formula obtained as the result of a regression calculation. To copy a resulting regression formula, press F6 (COPY).



```
LinearReg
    a =0.5
    b =999
    r =1
    r²=1
   MSe=0
y=ax+b
```

■ Tests, Confidence Interval, and Distribution Calculations

The STAT Mode includes functions for performing tests, and confidence interval and distribution calculations. You can find explanations of each of these functions in the following sections: 1-2 Tests, 1-3 Confidence Interval, and 1-4 Distribution.

•Parameter Settings

The following describes the two methods you can use to make parameter settings for test, confidence interval, and distribution calculations.

- Selection
  With this method, you press the function key that corresponds to the setting you want to select from the function menu.
- Value Input
  With this method, you directly input the parameter value you want to input. In this case, nothing appears in the function menu.

· Pressing ESC returns to the list input screen, with the cursor in the same position it was at before you started the parameter setting procedure.

· Pressing SHIFT ESC (QUIT) returns to the top of list input screen.

· Pressing EXE without pressing F1 (CALC) under "Execute" item advances to calculation execution. To return to the parameter setting screen, press ESC, AC, or EXE.

•Common Functions

- The symbol "■" appears in the upper right corner of the screen while execution of a calculation is being performed and while a graph is being drawn. Pressing AC during this time terminates the ongoing calculation or draw operation (AC Break).
- Pressing ESC or EXE while a calculation result or graph is on the display returns to the parameter setting screen. Pressing SHIFT ESC (QUIT) returns to the top of list input screen.

· Pressing AC while a calculation result is on the display returns to the parameter setting screen.

- Pressing CTRL F5 (G↔T) after drawing a graph switches to the parameter setting screen (G↔T function). Pressing CTRL F5 (G↔T) again returns to the graph screen.

· The G↔T function is disabled whenever you change a setting on the parameter setting screen, or when you perform a CTRL F3 (SET UP) or SHIFT OPTN (V-Window) operation.

- You can perform the PICT menu's screen save or recall functions after drawing a graph.

· The ZOOM function and SKETCH function are disabled.

The TRACE function is disabled, except for the graph display of two-way ANOVA.

The graph screen cannot be scrolled.

- After drawing a graph, you can use a Save Result feature to save calculation results to a specific list. Basically, all items are saved as they are displayed, except for the first line title.

· Each time you execute Save Result, any existing data in the list is replaced by the new results.

1-2 Tests (TEST)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

- F3(TEST) 1(Z) ... *Z* Tests (p. 1-2-2)
  2(T) ... *t* Tests (p. 1-2-10)
  3(χ^2) ... χ^2 Test (p. 1-2-18)
  4(F) ... 2-Sample *F* Test (p. 1-2-20)
  5(ANOVA) ... ANOVA (p. 1-2-22)

Z Tests

•*Z* Test Common Functions

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

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

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

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

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

•1-Sample *Z* Test

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

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

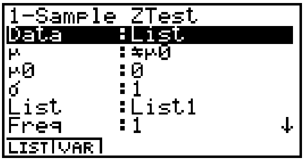
$\bar{x}$: mean of sample
μ_0 : assumed population mean
σ : population standard deviation
n : size of sample

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

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

Perform the following key operations from the statistical data list.

F3(TEST)
1(Z)
1(1-Smpl)



```
1-Sample ZTest
Data     :List
μ        :≠μ0
μ0       :0
σ        :1
List     :List1
Freq     :1
```

```
Save Res:None
Execute
```

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

Data	data type
μ	population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)
μ_0	assumed population mean
σ	population standard deviation ($\sigma > 0$)
List	list whose contents you want to use as data (List 1 to 20)
Freq	frequency (1 or List 1 to 20)
Save Res.....................	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

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

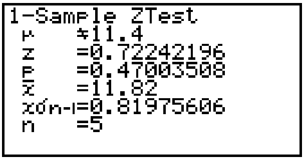
```
x̄        :0
n        :0
```

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

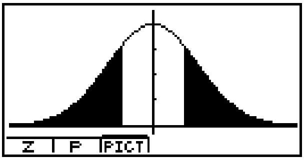
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
1-Sample ZTest
 μ    ≠11.4
 z    =0.72242196
 p    =0.47003508
 x̄    =11.82
 xσn-1=0.81975606
 n    =5
```



$\mu \neq 11.4$	direction of test
z	z score
p	p-value
$\bar{x}$	mean of sample
$x\sigma_{n-1}$	sample standard deviation (Displayed only for Data: List setting.)
n	size of sample

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

•2-Sample Z Test

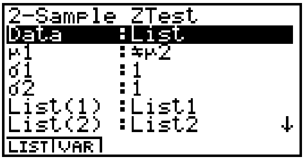
This test is used when the standard deviations for two populations are known to test the hypothesis. The **2-Sample Z Test** is applied to the normal distribution.

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

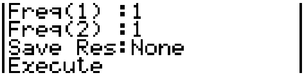
$\bar{x}_1$: mean of sample 1
$\bar{x}_2$: mean of sample 2
σ_1 : population standard deviation of sample 1
σ_2 : population standard deviation of sample 2
n_1 : size of sample 1
n_2 : size of sample 2

Perform the following key operations from the statistical data list.

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



```
2-Sample ZTest
Data       :List
μ1         :≠μ2
σ1         :1
σ2         :1
List(1)    :List1
List(2)    :List2        ↓
LIST VAR
```

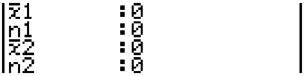


```
Freq(1) :1
Freq(2) :1
Save Res:None
Execute
```

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

Data	data type
μ_1	population mean value test conditions ("≠ μ_2" specifies two-tail test, "< μ_2" specifies one-tail test where sample 1 is smaller than sample 2, "> μ_2" specifies one-tail test where sample 1 is greater than sample 2.)
σ_1	population standard deviation of sample 1 ($\sigma_1 > 0$)
σ_2	population standard deviation of sample 2 ($\sigma_2 > 0$)
List(1)	list whose contents you want to use as sample 1 data (List 1 to 20)
List(2)	list whose contents you want to use as sample 2 data (List 1 to 20)
Freq(1)	frequency of sample 1 (1 or List 1 to 20)
Freq(2)	frequency of sample 2 (1 or List 1 to 20)
Save Res.....................	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

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



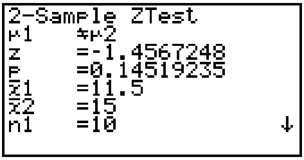
```
x̄1         :0
n1         :0
x̄2         :0
n2         :0
```

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

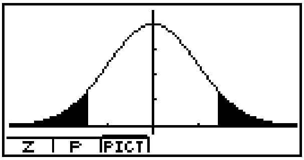
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
2-Sample ZTest
μ1    ≠μ2
z     =-1.4567248
p     =0.14519235
x̄1    =11.5
x̄2    =15
n1    =10           ↓
```



$\mu_1 \neq \mu_2$	direction of test
z	z score
p	p-value
$\bar{x}_1$	mean of sample 1
$\bar{x}_2$	mean of sample 2
$x_1\sigma_{n-1}$	standard deviation of sample 1 (Displayed only for Data: List setting.)
$x_2\sigma_{n-1}$	standard deviation of sample 2 (Displayed only for Data: List setting.)
n_1	size of sample 1
n_2	size of sample 2

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

•1-Prop Z Test

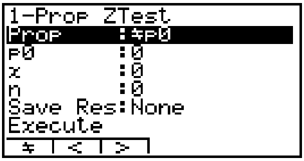
This test is used to test for an unknown proportion of successes. The **1-Prop Z Test** is applied to the normal distribution.

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

p_0 : expected sample proportion
n : size of sample

Perform the following key operations from the statistical data list.

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



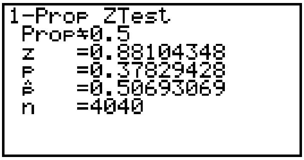
```
1-Prop ZTest
Prop     :≠p0
p0       :0
x        :0
n        :0
Save Res:None
Execute
```

Prop	sample proportion test conditions ("≠ p_0" specifies two-tail test, "< p_0" specifies lower one-tail test, "> p_0" specifies upper one-tail test.)
p_0	expected sample proportion ($0 < p_0 < 1$)
x	sample value ($x \geqq 0$ integer)
n	size of sample (positive integer)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

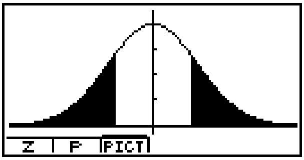
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
1-Prop ZTest
 Prop≠0.5
 z    =0.88104348
 p    =0.37829428
 p̂    =0.50693069
 n    =4040
```



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

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

•2-Prop Z Test

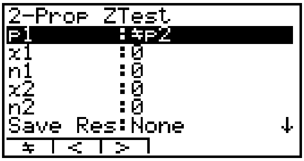
This test is used to compare the proportion of successes. The **2-Prop Z Test** is applied to the normal distribution.

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

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

Perform the following key operation from the statistical data list.

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



```
2-Prop ZTest
p1        :≠p2
x1        :0
n1        :0
x2        :0
n2        :0
Save Res:None        ↓
```

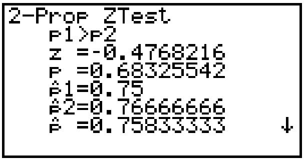
Execute

p_1	sample proportion test conditions ("≠ p_2" specifies two-tail test, "< p_2" specifies one-tail test where sample 1 is smaller than sample 2, "> p_2" specifies one-tail test where sample 1 is greater than sample 2.)
x_1	data value ($x_1 \geqq 0$ integer) of sample 1
n_1	size (positive integer) of sample 1
x_2	data value ($x_2 \geqq 0$ integer) of sample 2
n_2	size (positive integer) of sample 2
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

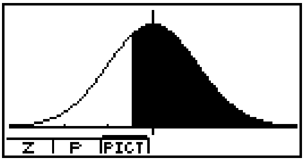
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
2-Prop ZTest
   p1>p2
   z =-0.4768216
   p =0.68325542
   p̂1=0.75
   p̂2=0.76666666
   p̂ =0.75833333     ↓
```



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

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

t Tests

• *t* Test Common Functions

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

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

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

Press ESC to clear the *t* score.

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

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

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

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

•1-Sample *t* Test

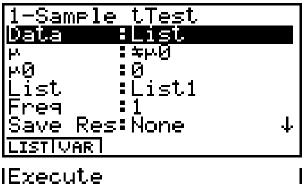
This test uses the hypothesis test for a single unknown population mean when the population standard deviation is unknown. The **1-Sample *t* Test** is applied to *t*-distribution.

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

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

Perform the following key operations from the statistical data list.

F3(TEST)
2(T)
1(1-Smpl)

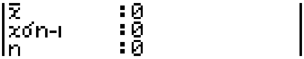


```
1-Sample tTest
Data     :List
μ        :≠μ0
μ0       :0
List     :List1
Freq     :1
Save Res:None       ↓
LIST VAR
Execute
```

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

Data	data type
μ	population mean value test conditions ("$\neq \mu_0$" specifies two-tail test, "$< \mu_0$" specifies lower one-tail test, "$> \mu_0$" specifies upper one-tail test.)
μ_0	assumed population mean
List	list whose contents you want to use as data (List 1 to 20)
Freq	frequency (1 or List 1 to 20)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

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



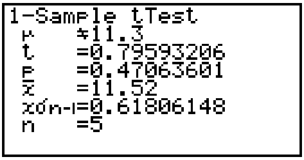
```
x̄        :0
xσn-1    :0
n        :0
```

$\bar{x}$	mean of sample
$x\sigma_{n-1}$	sample standard deviation ($x\sigma_{n-1} > 0$)
n	size of sample (positive integer)

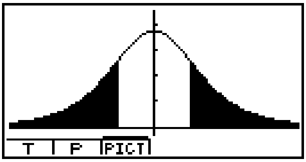
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
1-Sample tTest
 μ    ≠11.3
 t    =0.79593206
 p    =0.47063601
 x̄    =11.52
 xσn-1=0.61806148
 n    =5
```



$\mu \neq 11.3$	direction of test
t	t score
p	p-value
$\bar{x}$	mean of sample
$x\sigma_{n-1}$	sample standard deviation
n	size of sample

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

•2-Sample *t* Test

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

The following applies when pooling is in effect.

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

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

$$df = n_1 + n_2 - 2$$

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

The following applies when pooling is not in effect.

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

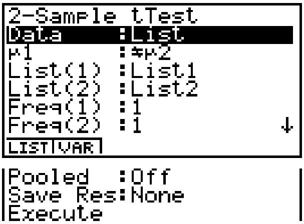
$$df = \frac{1}{\frac{C^2}{n_1-1}+\frac{(1-C)^2}{n_2-1}}$$

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

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

Perform the following key operations from the statistical data list.

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

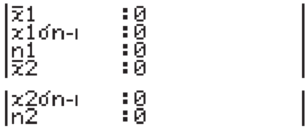


```
2-Sample tTest
Data      :List
μ1        :≠μ2
List(1)  :List1
List(2)  :List2
Freq(1)  :1
Freq(2)  :1          ↓
Pooled   :Off
Save Res:None
Execute
```

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

Data	data type
μ_1	sample mean value test conditions (“$\neq \mu_2$” specifies two-tail test, “$< \mu_2$” specifies one-tail test where sample 1 is smaller than sample 2, “$> \mu_2$” specifies one-tail test where sample 1 is greater than sample 2.)
List(1)	list whose contents you want to use as data of sample 1 (List 1 to 20)
List(2)	list whose contents you want to use as data of sample 2 (List 1 to 20)
Freq(1)	frequency of sample 1 (1 or List 1 to 20)
Freq(2)	frequency of sample 2 (1 or List 1 to 20)
Pooled	pooling On (in effect) or Off (not in effect)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

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



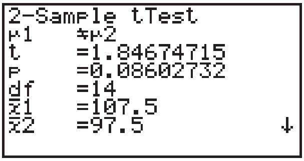
```
x̄1      :0
x1σn-1  :0
n1      :0
x̄2      :0

x2σn-1  :0
n2      :0
```

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

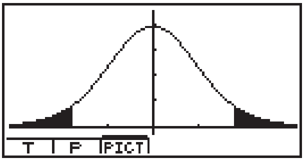
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
2-Sample tTest
μ1    ≠μ2
t     =1.84674715
p     =0.08602732
df    =14
x̄1    =107.5
x̄2    =97.5          ↓
```



$\mu_1 \neq \mu_2$	direction of test
t	t score
p	p-value
df	degrees of freedom
$\bar{x}_1$	mean of sample 1
$\bar{x}_2$	mean of sample 2
$x_1\sigma_{n\text{-}1}$	standard deviation of sample 1
$x_2\sigma_{n\text{-}1}$	standard deviation of sample 2
$x_p\sigma_{n\text{-}1}$	pooled sample standard deviation (Displayed only when Pooled: On setting.)
n_1	size of sample 1
n_2	size of sample 2

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

•LinearReg *t* Test

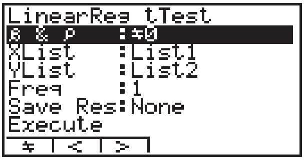
LinearReg *t* Test treats paired-variable data sets as (x, y) pairs, and uses the method of least squares to determine the most appropriate a, b coefficients of the data for the regression formula $y = a + bx$. It also determines the correlation coefficient and t value, and calculates the extent of the relationship between x and y.

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

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

Perform the following key operations from the statistical data list.

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



```
LinearReg tTest
β & ρ   :≠0
XList   :List1
YList   :List2
Freq    :1
Save Res:None
Execute
```

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

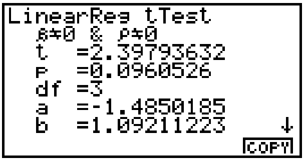
β & ρ	p-value test conditions ("≠ 0" specifies two-tail test, "< 0" specifies lower one-tail test, "> 0" specifies upper one-tail test.)
XList	list for x-axis data (List 1 to 20)
YList	list for y-axis data (List 1 to 20)
Freq	frequency (1 or List 1 to 20)
Save Res	list for storage of calculation results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

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

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

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

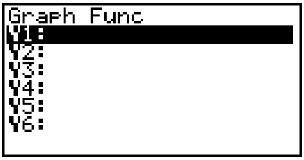
Calculation Result Output Example



```
LinearReg tTest
  β≠0 & ρ≠0
  t  =2.39793632
  p  =0.0960526
  df =3
  a  =-1.4850185
  b  =1.09211223    ↓
                 COPY
```

$\beta \neq 0$ & $\rho \neq 0$	direction of test
t	t score
p	p-value
df	degrees of freedom
a	constant term
b	coefficient
s	standard error
r	correlation coefficient
r^2	coefficient of determination

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



```
Graph Func
Y1:
Y2:
Y3:
Y4:
Y5:
Y6:
```

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

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

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

χ^2 Test

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

Expected counts

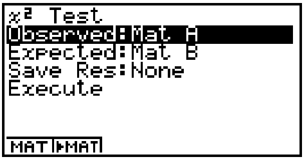
$$F_{ij} = \frac{\sum_{i=1}^{k} x_{ij} \times \sum_{j=1}^{\ell} x_{ij}}{\sum_{i=1}^{k} \sum_{j=1}^{\ell} x_{ij}}$$

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

Perform the following key operations from the statistical data list.

F3 (TEST)

3 (χ^2)



χ^2 Test
Observed:Mat A
Expected:Mat B
Save Res:None
Execute

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

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

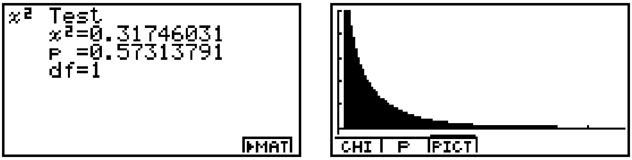
The matrix must be at least two lines by two columns. An error occurs if the matrix has only one line or one column.

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

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

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

Calculation Result Output Example



```
χ² Test
   χ²=0.31746031
   p =0.57313791
   df=1
```

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

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

- F1 (CHI) ... Displays χ^2 value.

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

Press ESC to clear the χ^2 value.

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

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

Press ESC to clear the p-value.

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

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

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

■ 2-Sample *F* Test

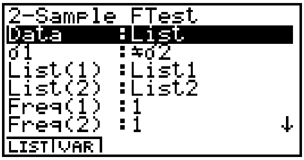
2-Sample *F* Test tests the hypothesis for the ratio of sample variances. The *F* Test is applied to the *F* distribution.

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

Perform the following key operations from the statistical data list.

F3(TEST)

4(F)



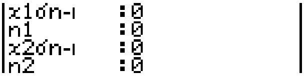
```
2-Sample FTest
Data      :List
σ1        :≠σ2
List(1)   :List1
List(2)   :List2
Freq(1)   :1
Freq(2)   :1
LIST VAR
```

```
Save Res:None
Execute
```

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

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

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



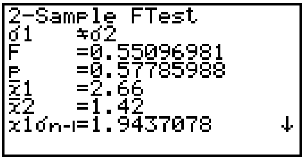
```
x1σn-1   :0
n1       :0
x2σn-1   :0
n2       :0
```

$x_1\sigma_{n-1}$	standard deviation ($x_1\sigma_{n-1} > 0$) of sample 1
n_1	size (positive integer) of sample 1
$x_2\sigma_{n-1}$	standard deviation ($x_2\sigma_{n-1} > 0$) of sample 2
n_2	size (positive integer) of sample 2

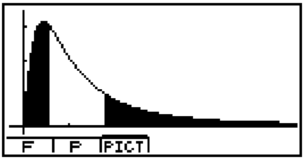
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
2-Sample FTest
σ1   ≠σ2
F    =0.55096981
p    =0.57785988
x̄1   =2.66
x̄2   =1.42
x1σn-1=1.9437078   ↓
```



$\sigma_1 \neq \sigma_2$	direction of test
F	F value
p	p-value
$\bar{x}_1$	mean of sample 1 (Displayed only for Data: List setting.)
$\bar{x}_2$	mean of sample 2 (Displayed only for Data: List setting.)
$x_1\sigma_{n-1}$	standard deviation of sample 1
$x_2\sigma_{n-1}$	standard deviation of sample 2
n_1	size of sample 1
n_2	size of sample 2

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

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

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

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

Press ESC to clear the F value.

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

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

Press ESC to clear the p-value.

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

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

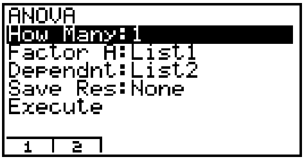
Executing an analysis function automatically stores the F and p values in alpha variables F and P, respectively.

ANOVA

ANOVA tests the hypothesis that the population means of the samples are equal when there are multiple samples.
One-Way ANOVA is used when there is one independent variable and one dependent variable.
Two-Way ANOVA is used when there are two independent variables and one dependent variable.

Perform the following key operations from the statistical data list.

F3(TEST)
5(ANOVA)



```
ANOVA
How Many:1
Factor A:List1
Dependnt:List2
Save Res:None
Execute
```

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

How Many	selects One-Way ANOVA or Two-Way ANOVA (number of levels)
Factor A	category list (List 1 to 20)
Dependnt	list to be used for sample data (List 1 to 20)
Save Res	first list for storage of calculation results (None or List 1 to 16)*[1]
Execute	executes a calculation or draws a graph (Two-Way ANOVA only)

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

Factor B	category list (List 1 to 20)

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

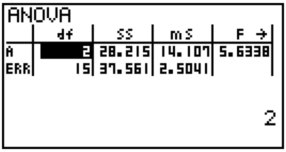
- F1(CALC) ... Performs the calculation.
- F6(DRAW) ... Draws the graph (Two-Way ANOVA only).

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

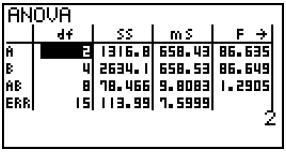
---

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

Calculation Result Output Example



```
ANOVA
    |  df |   SS  |  mS  |  F →|
A   |    2| 28.215|14.107|5.6338|
ERR |   15| 37.561|2.5041|
                               2
```



```
ANOVA
    |  df |   SS  |  mS  |  F →|
A   |    2| 1316.8|658.43|86.635|
B   |    4| 2634.1|658.53|86.649|
AB  |    8| 78.466|9.8083|1.2905|
ERR |   15| 113.99|7.5999|
                               2
```

One-Way ANOVA

Line 1 (A)	Factor A *df* value, *SS* value, *MS* value, *F* value, p-value
Line 2 (ERR)	Error *df* value, *SS* value, *MS* value

Two-Way ANOVA

Line 1 (A)	Factor A *df* value, *SS* value, *MS* value, *F* value, p-value
Line 2 (B)	Factor B *df* value, *SS* value, *MS* value, *F* value, p-value
Line 3 (AB)	Factor A × Factor B *df* value, *SS* value, *MS* value, *F* value, p-value *Line 3 does not appear when there is only one observation in each cell.
Line 4 (ERR)	Error *df* value, *SS* value, *MS* value

F	*F* value
p	p-value
df	degrees of freedom
SS	sum of squares
MS	mean squares

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

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

- F1 (TRACE) ... Trace function

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

Press ESC to clear the pointer from the display.

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

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

ANOVA (Two-Way)

•Description

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

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

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

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

•Solution

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

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

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

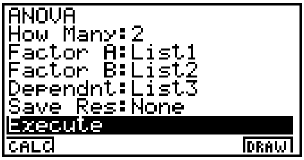
- Time differential (A) level of significance P = 0.2458019517
  The level of significance (p = 0.2458019517) is greater than the significance level (0.05), so the hypothesis is not rejected.

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

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

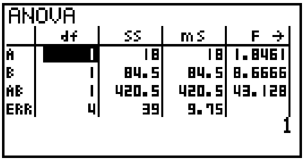
  The above test indicates that the time differential is not significant, the temperature differential is significant, and interaction is highly significant.

•Input Example

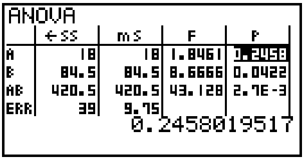


```
ANOVA
How Many:2
Factor A:List1
Factor B:List2
Dependnt:List3
Save Res:None
Execute
```

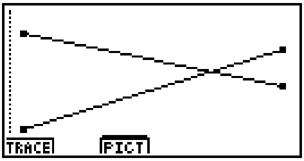
•Results



```
ANOVA
      df     SS     mS     F →
A      1     18     18  1.8461
B      1   84.5   84.5  8.6666
AB     1  420.5  420.5  43.128
ERR    4     39   9.75
                             1
```



```
ANOVA
     ←SS     mS      F      P
A     18     18  1.8461  0.2458
B   84.5   84.5  8.6666  0.0422
AB 420.5  420.5  43.128  2.7E-3
ERR   39   9.75
                  0.2458019517
```



1-3 Confidence Interval (INTR)

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

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

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

1-Sample Z Interval calculates the confidence interval for an unknown population mean when the population standard deviation is known.

2-Sample Z Interval calculates the confidence interval for the difference between two population means when the population standard deviations of two samples are known.

1-Prop Z Interval calculates the confidence interval for an unknown proportion of successes.

2-Prop Z Interval calculates the confidence interval for the difference between the propotion of successes in two populations.

1-Sample t Interval calculates the confidence interval for an unknown population mean when the population standard deviation is unknown.

2-Sample t Interval calculates the confidence interval for the difference between two population means when both population standard deviations are unknown.

On the initial STAT Mode screen, press F4 (INTR) to display the confidence interval menu, which contains the following items.

- F4(INTR) 1(Z) ... Z intervals (p. 1-3-3)
  2(T) ... t intervals (p. 1-3-8)

There is no graphing for confidence interval functions.

•General Confidence Interval Precautions

Inputting a value in the range of 0 ≦ C-Level < 1 for the C-Level setting sets you value you input. Inputting a value in the range of 1 ≦ C-Level < 100 sets a value equivalent to your input divided by 100.

Inputting a value of 100 or greater, or a negative value causes an error (Ma ERROR).

■ Z Interval

•1-Sample Z Interval

1-Sample Z Interval calculates the confidence interval for an unknown population mean when the population standard deviation is known.

The following is the confidence interval.

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

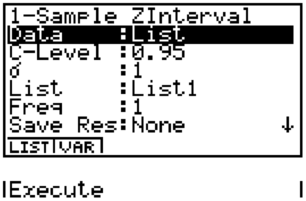
$$Right = \bar{x} + Z\left(\frac{\alpha}{2}\right)\frac{\sigma}{\sqrt{n}}$$

However, α is the level of significance. The value 100 (1 – α) % is the confidence level.

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

Perform the following key operations from the statistical data list.

F4(INTR)
1(Z)
1(1-Smpl)

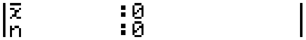


```
1-Sample ZInterval
Data    :List
C-Level :0.95
σ       :1
List    :List1
Freq    :1
Save Res:None        ↓
LIST VAR

Execute
```

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

Data	data type
C-Level	confidence level (0 ≦ C-Level < 1)
σ	population standard deviation (σ > 0)
List	list whose contents you want to use as sample data (List 1 to 20)
Freq	sample frequency (1 or List 1 to 20)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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



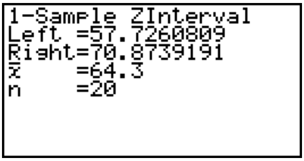
```
x̄          :0
n          :0
```

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

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

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

Calculation Result Output Example



```
1-Sample ZInterval
Left =57.7260809
Right=70.8739191
x̄    =64.3
n    =20
```

Left	interval lower limit (left edge)
Right	interval upper limit (right edge)
$\bar{x}$	mean of sample
$x\sigma_{n\text{-}1}$	sample standard deviation (Displayed only for Data: List setting.)
n	size of sample

• 2-Sample *Z* Interval

2-Sample *Z* Interval calculates the confidence interval for the difference between two population means when the population standard deviations of two samples are known. The following is the confidence interval. The value 100 (1 – α) % is the confidence level.

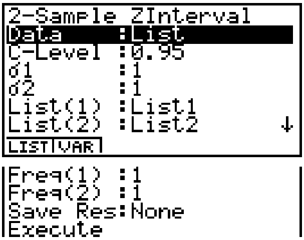
$$Left = (\bar{x}_1 - \bar{x}_2) - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}$$

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

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

Perform the following key operations from the statistical data list.

F4 (INTR)
1 (Z)
2 (2-Smpl)



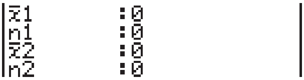
```
2-Sample ZInterval
Data    :List
C-Level :0.95
σ1      :1
σ2      :1
List(1) :List1
List(2) :List2
```

```
Freq(1) :1
Freq(2) :1
Save Res:None
Execute
```

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

Data	data type
C-Level	confidence level (0 ≦ C-Level < 1)
σ_1	population standard deviation of sample 1 ($\sigma_1 > 0$)
σ_2	population standard deviation of sample 2 ($\sigma_2 > 0$)
List(1)	list whose contents you want to use as data of sample 1 (List 1 to 20)
List(2)	list whose contents you want to use as data of sample 2 (List 1 to 20)
Freq(1)	frequency of sample 1 (1 or List 1 to 20)
Freq(2)	frequency of sample 2 (1 or List 1 to 20)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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



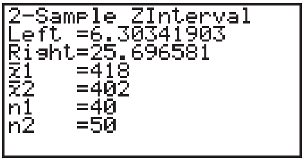
```
x̄1        :0
n1        :0
x̄2        :0
n2        :0
```

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

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

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

Calculation Result Output Example



```
2-Sample ZInterval
Left =6.30341903
Right=25.696581
x̄1   =418
x̄2   =402
n1   =40
n2   =50
```

Left	interval lower limit (left edge)
Right	interval upper limit (right edge)
$\bar{x}_1$	mean of sample 1
$\bar{x}_2$	mean of sample 2
$x_1\sigma_{n-1}$	standard deviation of sample 1 (Displayed only for Data: List setting.)
$x_2\sigma_{n-1}$	standard deviation of sample 2 (Displayed only for Data: List setting.)
n_1	size of sample 1
n_2	size of sample 2

•1-Prop Z Interval

1-Prop Z Interval uses the number of data to calculate the confidence interval for an unknown proportion of successes.

The following is the confidence interval. The value 100 (1 – α) % is the confidence level.

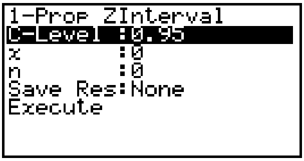
$$Left = \frac{x}{n} - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{1}{n}\left(\frac{x}{n}\left(1-\frac{x}{n}\right)\right)}$$

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

n : size of sample
x : data

Perform the following key operations from the statistical data list.

F4 (INTR)
1 (Z)
3 (1-Prop)



```
1-Prop ZInterval
C-Level :0.95
x       :0
n       :0
Save Res:None
Execute
```

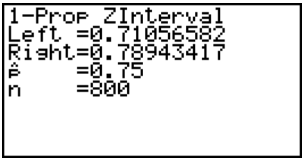
Data is specified using parameter specification. The following shows the meaning of each item.

C-Level	confidence level (0 ≦ C-Level < 1)
x	data (0 or positive integer)
n	size of sample (positive integer)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

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

Calculation Result Output Example



```
1-Prop ZInterval
Left =0.71056582
Right=0.78943417
p̂    =0.75
n    =800
```

Left	interval lower limit (left edge)
Right	interval upper limit (right edge)
$\hat{p}$	estimated sample proportion
n	size of sample

• 2-Prop *Z* Interval

2-Prop *Z* Interval uses the number of data items to calculate the confidence interval for the defference between the proportion of successes in two populations.

The following is the confidence interval. The value 100 (1 – α) % is the confidence level.

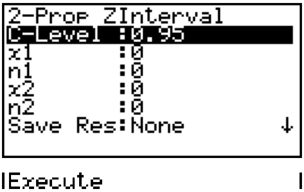
$$Left = \frac{x_1}{n_1} - \frac{x_2}{n_2} - Z\left(\frac{\alpha}{2}\right)\sqrt{\frac{\frac{x_1}{n_1}\left(1-\frac{x_1}{n_1}\right)}{n_1}+\frac{\frac{x_2}{n_2}\left(1-\frac{x_2}{n_2}\right)}{n_2}}$$

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

n_1, n_2 : size of sample
x_1, x_2 : data

Perform the following key operations from the statistical data list.

F4 (INTR)
1 (Z)
4 (2-Prop)



```
2-Prop ZInterval
C-Level :0.95
x1      :0
n1      :0
x2      :0
n2      :0
Save Res:None        ↓
Execute
```

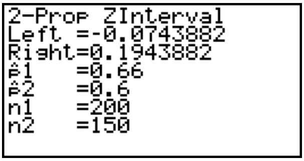
Data is specified using parameter specification. The following shows the meaning of each item.

C-Level	confidence level (0 ≦ C-Level < 1)
x_1	data value (x_1 ≧ 0) of sample 1
n_1	size (positive integer) of sample 1
x_2	data value (x_2 ≧ 0) of sample 2
n_2	size (positive integer) of sample 2
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

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

Calculation Result Output Example



```
2-Prop ZInterval
Left =-0.0743882
Right=0.1943882
p̂1   =0.66
p̂2   =0.6
n1   =200
n2   =150
```

Left	interval lower limit (left edge)
Right	interval upper limit (right edge)
$\hat{p}_1$	estimated sample propotion for sample 1
$\hat{p}_2$	estimated sample propotion for sample 2
n_1	size of sample 1
n_2	size of sample 2

t Interval

• 1-Sample *t* Interval

1-Sample *t* Interval calculates the confidence interval for an unknown population mean when the population standard deviation is unknown.

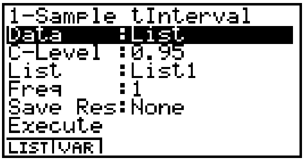
The following is the confidence interval. The value 100 (1 – α) % is the confidence level.

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

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

Perform the following key operations from the statistical data list.

F4(INTR)
2(T)
1(1-Smpl)

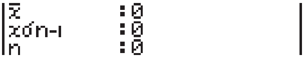


```
1-Sample tInterval
Data     :List
C-Level  :0.95
List     :List1
Freq     :1
Save Res:None
Execute
```

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

Data	data type
C-Level	confidence level (0 ≦ C-Level < 1)
List	list whose contents you want to use as sample data (List 1 to 20)
Freq	sample frequency (1 or List 1 to 20)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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



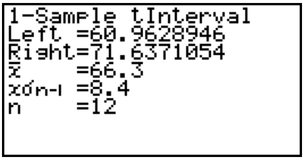
```
x̄       :0
xσn-1   :0
n       :0
```

$\bar{x}$	mean of sample
$x\sigma_{n\text{-}1}$	sample standard deviation ($x\sigma_{n\text{-}1} \geqq 0$)
n	size of sample (positive integer)

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

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

Calculation Result Output Example



```
1-Sample tInterval
Left =60.9628946
Right=71.6371054
x̄     =66.3
xσn-1 =8.4
n     =12
```

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

• 2-Sample *t* Interval

2-Sample *t* Interval calculates the confidence interval for the difference between two population means when both population standard deviations are unknown. The *t* interval is applied to *t* distribution.

The following confidence interval applies when pooling is in effect. The value 100 (1 – α) % is the confidence level.

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

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

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

The following confidence interval applies when pooling is not in effect. The value 100 (1 – α) % is the confidence level.

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

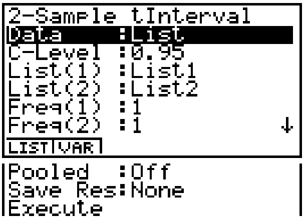
$$Right = (\bar{x}_1 - \bar{x}_2) + t_{df}\left(\frac{\alpha}{2}\right)\sqrt{\left(\frac{x_1\sigma_{n-1}{}^2}{n_1} + \frac{x_2\sigma_{n-1}{}^2}{n_2}\right)}$$

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

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

Perform the following key operations from the statistical data list.

$\boxed{\text{F4}}$(INTR)
$\boxed{2}$(T)
$\boxed{2}$(2-Smpl)

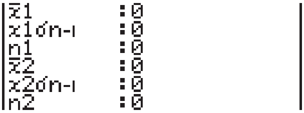


```
2-Sample tInterval
Data      :List
C-Level   :0.95
List(1)   :List1
List(2)   :List2
Freq(1)   :1
Freq(2)   :1
LIST VAR
Pooled    :Off
Save Res:None
Execute
```

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

Data	data type
C-Level	confidence level (0 ≦ C-Level < 1)
List(1)	list whose contents you want to use as data of sample 1 (List 1 to 20)
List(2)	list whose contents you want to use as data of sample 2 (List 1 to 20)
Freq(1)	frequency of sample 1 (1 or List 1 to 20)
Freq(2)	frequency of sample 2 (1 or List 1 to 20)
Pooled	pooling On (in effect) or Off (not in effect)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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



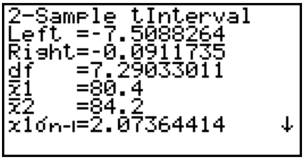
```
x̄1        :0
x1σn-1    :0
n1        :0
x̄2        :0
x2σn-1    :0
n2        :0
```

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

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

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

Calculation Result Output Example



```
2-Sample tInterval
Left =-7.5088264
Right=-0.0911735
df   =7.29033011
x̄1   =80.4
x̄2   =84.2
x1σn-1=2.07364414    ↓
```

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

1-4 Distribution (DIST)

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

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

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

Normal probability density calculates the probability density of normal distribution from a specified x value.

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

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

Student- t **probability density** calculates t probability density from a specified x value.

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

Like t distribution, distribution probability can also be calculated for χ^2, F, **Binomial**, **Poisson**, and **Geometric** distributions.

On the initial STAT Mode screen, press F5 (DIST) to display the distribution menu, which contains the following items.

- F5(DIST) 1 (Norm) ... Normal distribution (p. 1-4-3)
  2 (T) ... Student-t distribution (p. 1-4-7)
  3 (χ^2) ... χ^2 distribution (p. 1-4-9)
  4 (F) ... F distribution (p. 1-4-12)
  5 (Binmal) ... Binomial distribution (p. 1-4-16)
  6 (Poissn) ... Poisson distribution (p. 1-4-19)
  7 (Geo) ... Geometric distribution (p. 1-4-21)

•Common Distribution Functions

After drawing a graph, you can use the P-CAL function to calculate an estimated p-value for a particular x value.

The following is the general procedure for using the P-CAL function.

1. After drawing a graph, press F1 (P-CAL) to display the x value input dialog box.
2. Input the value you want for x and then press EXE.
- This causes the x and p values to appear at the bottom of the display, and moves the pointer to the corresponding point on the graph.
3. Pressing X,θ,T or a number key at this time causes the x value input dialog box to reappear so you can perform another estimated value calculation if you want.
4. After you are finished, press ESC to clear the coordinate values and the pointer from the display.

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

Normal Distribution

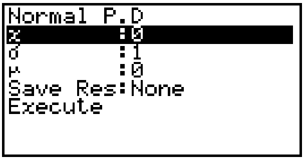
•Normal Probability Density

Normal probability density calculates the probability density of nomal distribution from a specified *x* value. Normal probability density is applied to standard normal distribution.

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

Perform the following key operations from the statistical data list.

F5 (DIST)
1 (Norm)
1 (P.D)



```
Normal P.D
x          :0
σ          :1
μ          :0
Save Res:None
Execute
```

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

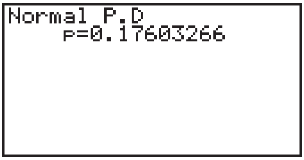
x	data
σ	standard deviation ($\sigma > 0$)
μ	mean
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

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

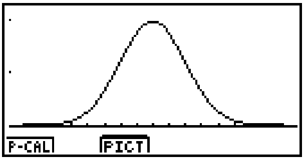
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
Normal P.D
     p=0.17603266
```



p .... normal probability density

V-Window settings for graph drawing are set automatically when the SET UP screen's [Stat Wind] setting is [Auto]. Current V-Window settings are used for graph drawing when the [Stat Wind] setting is [Manual].

•Normal Distribution Probability

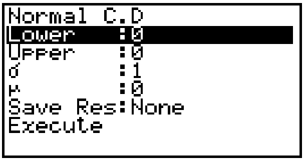
Normal distribution probability calculates the probability of normal distribution data falling between two specific values.

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

a : lower boundary
b : upper boundary

Perform the following key operations from the statistical data list.

F5 (DIST)
1 (Norm)
2 (C.D)



```
Normal C.D
Lower    :0
Upper    :0
σ        :1
μ        :0
Save Res:None
Execute
```

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

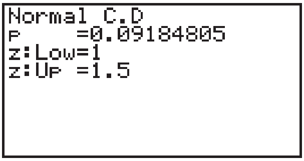
Lower	lower boundary
Upper	upper boundary
σ	standard deviation (σ > 0)
μ	mean
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

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

There is no graphing for normal distribution probability.

Calculation Result Output Example



```
Normal C.D
p     =0.09184805
z:Low=1
z:Up =1.5
```

p	normal distribution probability
z:Low	z:Low value (converted to standardize z score for lower value)
z:Up	z:Up value (converted to standardize z score for upper value)

•Inverse Cumulative Normal Distribution

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

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

Tail: Left upper boundary of integration interval α = ?

$$\int_{\alpha}^{+\infty} f(x)dx = p$$

Tail: Right lower boundary of integration interval α = ?

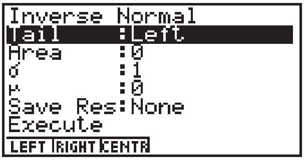
$$\int_{\alpha}^{\beta} f(x)dx = p$$

Tail: Central upper and lower boundaries of integration interval α = ? β = ?

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

Perform the following key operations from the statistical data list.

F5(DIST)
1(Norm)
3(Invrse)



```
Inverse Normal
Tail      :Left
Area      :0
σ         :1
μ         :0
Save Res:None
Execute
```

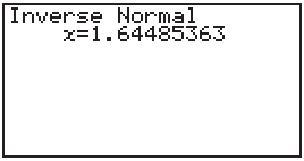
Data is specified using parameter specification. The following shows the meaning of each item.

Tail	probability value tail specification (Left, Right, Central)
Area	probability value (0 ≦ Area ≦ 1)
σ	standard deviation (σ > 0)
μ	mean
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

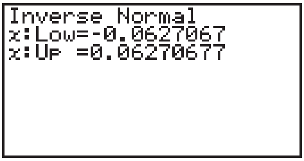
After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

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

Calculation Result Output Examples



```
Inverse Normal
     x=1.64485363
```



```
Inverse Normal
x:Low=-0.0627067
x:Up =0.06270677
```

x .... inverse cumulative normal distribution
(Tail:Left upper boundary of integration interval)
(Tail:Right lower boundary of integration interval)
(Tail:Central upper and lower boundaries of integration interval)

There is no graphing for inverse cumulative normal distribution.

Student-*t* Distribution

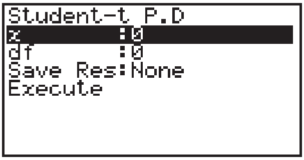
•Student-*t* Probability Density

Student-*t* probability density calculates *t* probability density from a specified *x* value.

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

Perform the following key operations from the statistical data list.

F5 (DIST)
2 (T)
1 (P.D)



```
Student-t P.D
x         :0
df        :0
Save Res:None
Execute
```

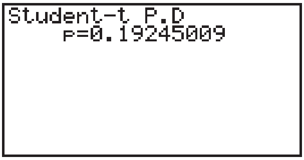
Data is specified using parameter specification. The following shows the meaning of each item.

x	data
df	degrees of freedom ($df > 0$)
Save Res.....................	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

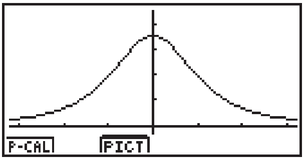
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
Student-t P.D
     p=0.19245009
```



p .... Student-*t* probability density

Current V-Window settings are used for graph drawing when the SET UP screen's [Stat Wind] setting is [Manual]. The V-Window settings below are set automatically when the [Stat Wind] setting is [Auto].

Xmin = –3.2, *Xmax* = 3.2, *Xscale* = 1,

Ymin = –0.1, *Ymax* = 0.45, *Yscale* = 0.1

•Student-*t* Distribution Probability

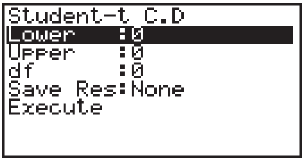
Student-*t* distribution probability calculates the probability of *t* distribution data falling between two specific values.

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

a : lower boundary
b : upper boundary

Perform the following key operations from the statistical data list.

F5 (DIST)
2 (T)
2 (C.D)



```
Student-t C.D
Lower    :0
Upper    :0
df       :0
Save Res:None
Execute
```

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

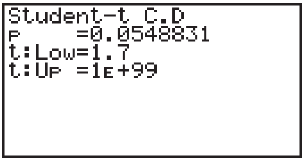
Lower	lower boundary
Upper	upper boundary
df	degrees of freedom ($df > 0$)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

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

There is no graphing for Student-*t* distribution probability.

Calculation Result Output Example



```
Student-t C.D
p     =0.0548831
t:Low=1.7
t:Up  =1E+99
```

p	Student-*t* distribution probability
t:Low	t:Low value (input lower value)
t:Up	t:Up value (input upper value)

■ χ^2 Distribution

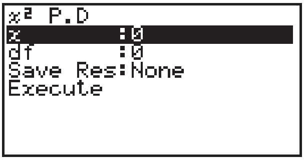
•χ^2 Probability Density

χ^2 probability density calculates the probability density function for the χ^2 distribution at a specified x value.

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

Perform the following key operations from the statistical data list.

F5(DIST)
3(χ^2)
1(P.D)



```
χ² P.D
x         :0
df        :0
Save Res:None
Execute
```

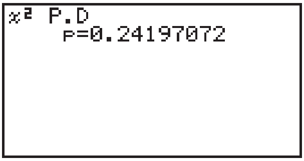
Data is specified using parameter specification. The following shows the meaning of each item.

x	data
df	degrees of freedom (positive integer)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

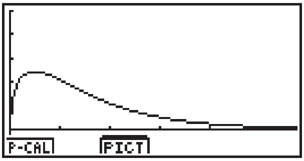
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
χ² P.D
    p=0.24197072
```



p .... χ^2 probability density

Current V-Window settings are used for graph drawing when the SET UP screen's [Stat Wind] setting is [Manual]. The V-Window settings below are set automatically when the [Stat Wind] setting is [Auto].

Xmin = 0, *Xmax* = 11.5, *Xscale* = 2,

Ymin = -0.1, *Ymax* = 0.5, *Yscale* = 0.1

•χ^2 Distribution Probability

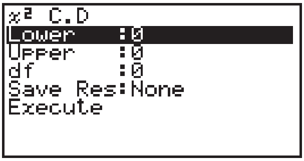
χ^2 distribution probability calculates the probability of χ^2 distribution data falling between two specific values.

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

a : lower boundary
b : upper boundary

Perform the following key operations from the statistical data list.

F5(DIST)
3(χ^2)
2(C.D)



```
χ² C.D
Lower    :0
Upper    :0
df       :0
Save Res:None
Execute
```

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

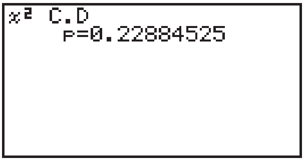
Lower	lower boundary
Upper	upper boundary
df	degrees of freedom (positive integer)
Save Res.....................	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

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

There is no graphing for χ^2 distribution probability.

Calculation Result Output Example



```
χ² C.D
    p=0.22884525
```

p .... χ^2 distribution probability

F Distribution

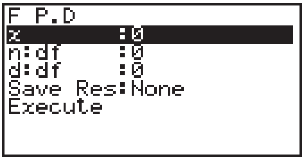
• F Probability Density

F probability density calculates the probability density function for the *F* distribution at a specified *x* value.

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

Perform the following key operations from the statistical data list.

F5 (DIST)
4 (F)
1 (P.D)



```
F P.D
x          :0
n:df       :0
d:df       :0
Save Res:None
Execute
```

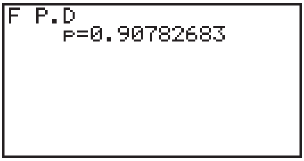
Data is specified using parameter specification. The following shows the meaning of each item.

x	data
n:*df*	numerator degrees of freedom (positive integer)
d:*df*	denominator degrees of freedom (positive integer)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation or draws a graph

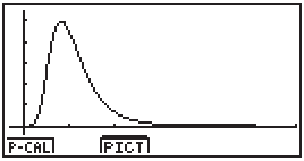
After setting all the parameters, align the cursor with [Execute] and then press one of the function keys shown below to perform the calculation or draw the graph.

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

Calculation Result Output Example



```
F P.D
    p=0.90782683
```



p .... F probability density

V-Window settings for graph drawing are set automatically when the SET UP screen's [Stat Wind] setting is [Auto]. Current V-Window settings are used for graph drawing when the [Stat Wind] setting is [Manual].

• *F* Distribution Probability

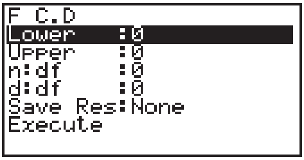
F distribution probability calculates the probability of *F* distribution data falling between two specific values.

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

a : lower boundary
b : upper boundary

Perform the following key operations from the statistical data list.

F5 (DIST)
4 (F)
2 (C.D)



```
F C.D
Lower    :0
Upper    :0
n:df     :0
d:df     :0
Save Res:None
Execute
```

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

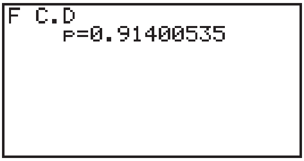
Lower	lower boundary
Upper	upper boundary
n:*df*	numerator degrees of freedom (positive integer)
d:*df*	denominator degrees of freedom (positive integer)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

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

There is no graphing for *F* distribution probability.

Calculation Result Output Example



```
F C.D
    p=0.91400535
```

p .... F distribution probability

Binomial Distribution

• Binomial Probability

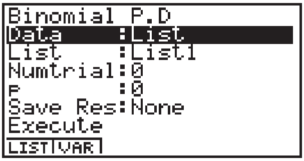
Binomial probability calculates a probability at a specified value for the discrete binomial distribution with the specified number of trials and probability of success on each trial.

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

p : success probability ($0 \leqq p \leqq 1$)
n : number of trials

Perform the following key operations from the statistical data list.

F5 (DIST)
5 (Binmal)
1 (P.D)



```
Binomial P.D
Data    :List
List    :List1
Numtrial:0
p       :0
Save Res:None
Execute
LIST VAR
```

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

Data	data type
List	list whose contents you want to use as specified data (List 1 to 20)
Numtrial	number of trials
p	success probability ($0 \leqq p \leqq 1$)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

```
x       :0
```

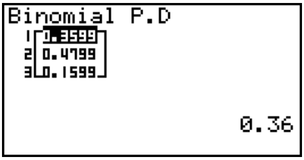
x	integer from 0 to n

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

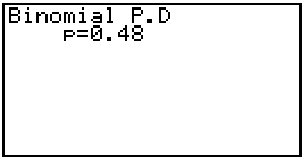
- F1 (CALC) ... Performs the calculation.

There is no graphing for binomial distribution.

Calculation Result Output Example



```
Binomial P.D
 1 0.3599
 2 0.4799
 3 0.1599

                0.36
```



```
Binomial P.D
    p=0.48
```

p .... binomial probability

•Binomial Cumulative Density

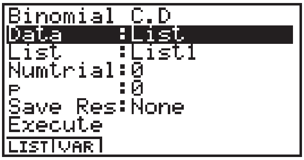
Binomial cumulative density calculates a cumulative probability at a specified value for the discrete binomial distribution with the specified number of trials and probability of success on each trial.

Perform the following key operations from the statistical data list.

F5 (DIST)

5 (Binmal)

2 (C.D)



```
Binomial C.D
Data     :List
List     :List1
Numtrial:0
p        :0
Save Res:None
Execute
```

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

Data	data type
List	list whose contents you want to use as specified data (List 1 to 20)
Numtrial	number of trials
p	success probability ($0 \leqq p \leqq 1$)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

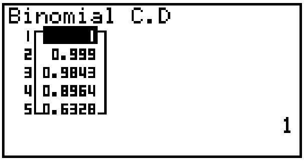
```
x        :0
```

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

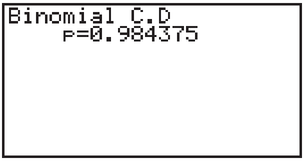
After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

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

Calculation Result Output Example



```
Binomial C.D
 1      1
 2  0.999
 3 0.9843
 4 0.8964
 5 0.6328
                    1
```



```
Binomial C.D
     p=0.984375
```

p .... probability of success

Poisson Distribution

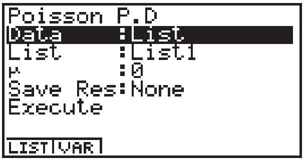
•Poisson Probability

Poisson probability calculates a probability at a specified value for the discrete Poisson distribution with the specified mean.

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

Perform the following key operations from the statistical data list.

F5(DIST)
6(Poissn)
1(P.D)



```
Poisson P.D
Data      :List
List      :List1
μ         :0
Save Res:None
Execute
```

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

Data	data type
List	list whose contents you want to use as specified data (List 1 to 20)
μ	mean (μ > 0)
Save Res.....................	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

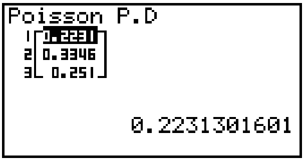
```
x         :0
```

x .... ($x \geqq 0$)

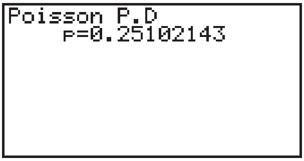
After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

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

Calculation Result Output Example



```
Poisson P.D
 1 [0.2231]
 2  0.3346
 3  0.251
                0.2231301601
```



```
Poisson P.D
     p=0.25102143
```

p .... Poisson probability

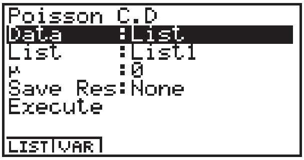
There is no graphing for Poisson distribution.

• Poisson Cumulative Density

Poisson cumulative density calculates a cumulative probability at specified value for the discrete Poisson distribution with the specified mean.

Perform the following key operations from the statistical data list.

F5(DIST)
6(Poissn)
2(C.D)



```
Poisson C.D
Data    :List
List    :List1
μ       :0
Save Res:None
Execute
```

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

Data	data type
List	list whose contents you want to use as specified data (List 1 to 20)
μ	mean ($\mu > 0$)
Save Res	list for storage of calculation results (None or List 1 to 20)
Execute	executes a caluculation

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

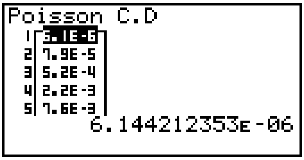
```
x       :0
```

x .... ($x \geqq 0$)

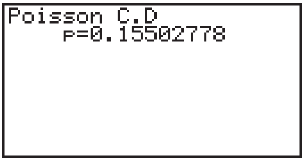
After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

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

Calculation Result Output Example



```
Poisson C.D
 1 6.1E-6
 2 7.9E-5
 3 5.2E-4
 4 2.2E-3
 5 7.6E-3
      6.144212353E-06
```



```
Poisson C.D
    p=0.15502778
```

p .... Poisson cumulative probability

Geometric Distribution

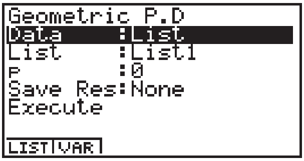
•Geometric Probability

Geometric probability calculates the probability at a specified value, and the number of the trial on which the first success occurs, for the geometric distribution with a specified probability of success.

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

Perform the following key operations from the statistical data list.

F5(DIST)
7(Geo)
1(P.D)



```
Geometric P.D
Data     :List
List     :List1
p        :0
Save Res:None
Execute
```

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

Data	data type
List	list whose contents you want to use as specified data (List 1 to 20)
p	success probability ($0 \leqq p \leqq 1$)
Save Res.....................	list for storage of calculation results (None or List 1 to 20)
Execute	executes a calculation

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

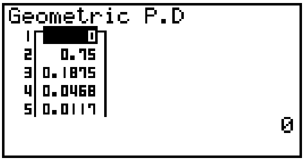
```
x        :0
```

x .... positive integer ($x \geqq 1$)

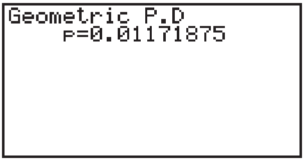
After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

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

Calculation Result Output Example



```
Geometric P.D
 1      0
 2   0.75
 3 0.1875
 4 0.0468
 5 0.0117
                0
```



```
Geometric P.D
    p=0.01171875
```

p .... geometric probability

There is no graphing for geometric distribution.

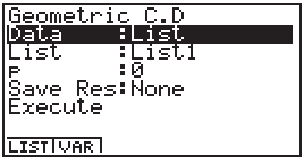
Positive integer number is calculated whether list data (Data:List) or *x* value (Data:variable) is specified.

•Geometric Cumulative Density

Geometric cumulative density calculates a cumulative probability at specified value, the number of the trial on which the first success occurs, for the discrete geometric distribution with the specified probability of success.

Perform the following key operations from the statistical data list.

F5(DIST)
7(Geo)
2(C.D)



```
Geometric C.D
Data     :List
List     :List1
p        :0
Save Res:None
Execute
```

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

Data .... data type
List .... list whose contents you want to use as specified data (List 1 to 20)
p .... success probability (0 ≦ *p* ≦ 1)
Save Res .... list for storage of calculation results (None or List 1 to 20)
Execute .... executes a calculation

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

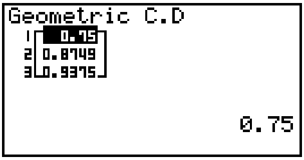
```
x        :0
```

x .... positive integer (*x* ≧ 1)

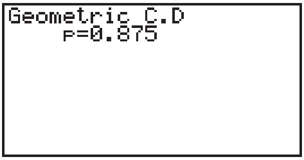
After setting all the parameters, align the cursor with [Execute] and then press the function key shown below to perform the calculation.

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

Calculation Result Output Example



```
Geometric C.D
 1[  0.75]
 2 0.8749
 3 0.9375]

               0.75
```



```
Geometric C.D
     p=0.875
```

p .... geometric cumulative probability

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

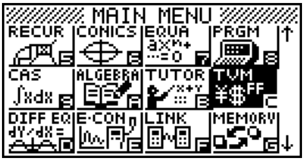
Chapter 2

Financial Calculation (TVM)

2-1 Before Performing Financial Calculations

TVM Mode

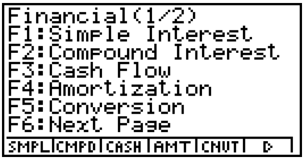
On the Main Menu, select the TVM icon.



* The above shows the ALGEBRA FX 2.0 PLUS screen.

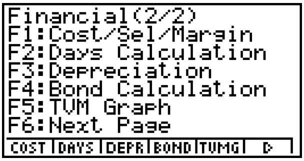
Entering the TVM Mode displays the Financial screen like the one shown below.

Financial 1 screen



Financial(1/2)
F1:Simple Interest
F2:Compound Interest
F3:Cash Flow
F4:Amortization
F5:Conversion
F6:Next Page

Financial 2 screen



Financial(2/2)
F1:Cost/Sel/Margin
F2:Days Calculation
F3:Depreciation
F4:Bond Calculation
F5:TVM Graph
F6:Next Page

- F1 (SMPL) .... Simple interest
- F2 (CMPD) ... Compound interest
- F3 (CASH) .... Cash flow (investment appraisal)
- F4 (AMT) ...... Amortization
- F5 (CNVT) .... Interest rate conversion
- F6 (▷) F1 (COST) ... Cost, selling price, margin
    F2 (DAYS) ... Day/date calculations
    F3 (DEPR) ... Depreciation
    F4 (BOND) ... Bonds
    F5 (TVMG) ... TVM (compound interest simulation) graph

SET UP Items

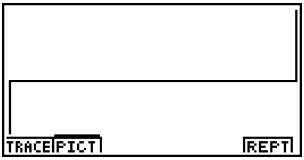
- **Payment**
  - {**BGN**}/{**END**} .... Specifies {beginning of the period} / {end of the period} payment
- **Date Mode**
  - {**365**}/{**360**} .... Specifies calculation according to a {365-day} / {360-day} year
- **Periods/YR. (Bond)**
  - {**Annual**}/{**SEMI**} ... Indicates an {annual} / {semi-annual} period

Note the following points regarding SET UP screen settings whenever using the Financial Mode.

- Drawing a financial graph while the Label item is turned on, displays the label CASH for the vertical axis (deposits, withdrawals), and TIME for the horizontal axis (frequency). Axis labels do not appear on the TVM graph.
- The number of display digits applied in the Financial Mode is different from the number of digits used in other modes. The calculators automatically reverts to Norm 1 whenever you enter the Financial Mode, which cancels a Sci (number of significant digits) or Eng (engineering notation) setting made in another mode.

Graphing in the TVM Mode

After performing a financial calculation, you can use F6 (GRPH) to graph the results as shown below.



- Pressing F1 (TRACE) while a graph is on the display activates Trace, which can be used to look up other financial values. In the case of simple interest, for example, pressing ▶ displays *PV*, *SI*, and *SFV*. Pressing ◀ displays the same values in reverse sequence.
- Zoom, Scroll, and Sketch cannot be used in the Financial Mode.
- Whether you should use a positive or a negative value for the present value (PV) or the purchase price (PRC) depends on the type of calculation you are trying to perform.
- Note that graphs should be used only for reference purposes when viewing TVM Mode calculation results.
- Note that calculation results produced in this mode should be regarded as reference values only.
- Whenever performing an actual financial transaction, be sure to check any calculation results obtained using this calculator with against the figures calculated by your financial institution.

2-2 Simple Interest

This calculator uses the following formulas to calculate simple interest.

•Formula

365-day Mode $SI' = \frac{n}{365} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

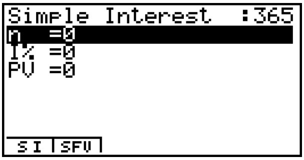
360-day Mode $SI' = \frac{n}{360} \times PV \times i \quad \left(i = \frac{I\%}{100}\right)$

SI : interest
n : number of interest periods
PV : principal
$I\%$: annual interest
SFV : principal plus interest

$$SI = -SI'$$
$$SFV = -(PV + SI')$$

Press F1(SMPL) from the Financial 1 screen to display the following input screen for simple interest.

F1(SMPL)



```
Simple Interest  :365
n  =0
I% =0
PV =0
```

n .... number of interest periods (days)

$I\%$ .... annual interest rate

PV .... principal

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

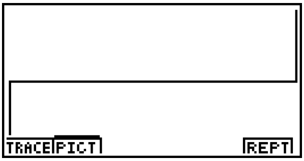
- F1(SI) .... Simple interest
- F2(SFV) ... Simple future value

```
Simple Interest  :365
SI =295.890411
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

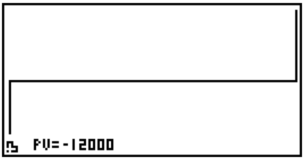
Use the following function keys to maneuver between calculation result screens.

- F1(REPT) ... Parameter input screen
- F6(GRPH) ... Draws graph



After drawing a graph, you can press F1(TRACE) to turn on trace and read calculation results along the graph.

Each press of ▶ while trace is turned on cycles the displayed value in the sequence: present value (PV) → simple interest (SI) → simple future value (SFV). Pressing ◀ cycles in the reverse direction.



PV=-12000

Press ESC to turn off trace.

Press ESC again to return to the parameter input screen.

2-3 Compound Interest

This calculator uses the following standard formulas to calculate compound interest.

•Formula I

$$PV+PMT\times\frac{(1+i\times S)[(1+i)^n-1]}{i(1+i)^n}+FV\frac{1}{(1+i)^n}=0 \qquad \left(i=\frac{I\%}{100}\right)$$

Here:

$$PV=-(PMT\times\alpha+FV\times\beta)$$

$$FV=-\frac{PMT\times\alpha+PV}{\beta}$$

$$PMT=-\frac{PV+FV\times\beta}{\alpha}$$

$$n=\frac{\log\left\{\dfrac{(1+iS)\,PMT-FVi}{(1+iS)\,PMT+PVi}\right\}}{\log(1+i)}$$

$$\alpha=\frac{(1+i\times S)[(1+i)^n-1]}{i(1+i)^n}$$

$$\beta=\frac{1}{(1+i)^n}$$

PV : present value
FV : future value
PMT : payment
n : number of compound periods
$I\%$: annual interest rate

i is calculated using Newton's Method.

$S = 0$ assumed for end of term
$S = 1$ assumed for beginning of term

$F(i)$ = Formula I

$$F(i)=\frac{PMT}{i}\left[-\frac{(1+iS)[1-(1+i)^{-n}]}{i}+(1+iS)[n(1+i)^{-n-1}]\right.$$
$$\left.+S[1-(1+i)^{-n}]\right]-nFV(1+i)^{-n-1}$$

•Formula II ($I\%$ = 0)

$$PV+PMT\times n+FV=0$$

Here:

$$PV=-(PMT\times n+FV)$$

$$FV = -\left(PMT \times n + PV\right)$$

$$PMT = -\frac{PV + FV}{n}$$

$$n = -\frac{PV + FV}{PMT}$$

- A deposit is indicated by a plus sign (+), while a withdrawal is indicated by a minus sign (–).

●Converting between the nominal interest rate and effective interest rate

The nominal interest rate (*I*% value input by user) is converted to an effective interest rate (*I*%') when the number of installments per year (*P/Y*) is different from the number of compound interest calculation periods (*C/Y*). This conversion is required for installment savings accounts, loan repayments, etc.

$$I\%' = \left\{ \left(1 + \frac{I\%}{100 \times [C/Y]}\right)^{\frac{[C/Y]}{[P/Y]}} - 1 \right\} \times 100$$

P/Y: installment periods per year
C/Y: compounding periods per year

When calculating n, PV, PMT, FV

The following calculation is performed after conversion from the nominal interest rate to the effective interest rate, and the result is used for all subsequent calculations.

$$i = I\%' \div 100$$

When calculating $I\%$

After *I*% is obtained, the following calculation is performed to convert to *I*%'.

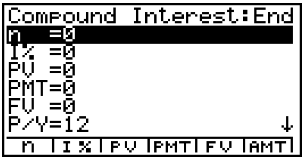
$$I\%' = \left\{ \left(1 + \frac{I\%}{100}\right)^{\frac{[P/Y]}{[C/Y]}} - 1 \right\} \times [C/Y] \times 100$$

P/Y: installment periods per year
C/Y: compounding periods per year

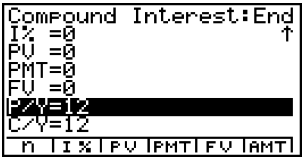
The value of *I*%' is returned as the result of the *I*% calculation.

Press F2(CMPD) from the Financial 1 screen to display the following input screen for compound interest.

F2(CMPD)



```
Compound Interest:End
n  =0
I% =0
PV =0
PMT=0
FV =0
P/Y=12               ↓
```



```
Compound Interest:End
I% =0                ↑
PV =0
PMT=0
FV =0
P/Y=12
C/Y=12
```

n	number of compound periods
I%	annual interest rate
PV	present value (loan amount in case of loan; principal in case of savings)
PMT	payment for each installment (payment in case of loan; deposit in case of savings)
FV	future value (unpaid balance in case of loan; principal plus interest in case of savings)
P/*Y*	installment periods per year
C/*Y*	compounding periods per year

Important!

Inputting Values

A period (n) is expressed as a positive value. Either the present value (PV) or future value (FV) is positive, while the other (PV or FV) is negative.

Precision

This calculator performs interest calculations using Newton's Method, which produces approximate values whose precision can be affected by various calculation conditions. Because of this, interest calculation results produced by this calculator should be used keeping the above limitation in mind or the results should be verified.

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

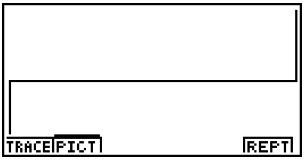
- F1(n) .... Number of compound periods
- F2(I%) .... Annual interest rate
- F3(PV) .... Present value (Loan: loan amount; Savings: balance)
- F4(PMT) .... Payment (Loan: installment; Savings: deposit)
- F5(FV) .... Future value (Loan: unpaid balance; Savings: principal plus interest)
- F6(AMT) .... Amortization screen

Compound Interest
I% =0.5070905364

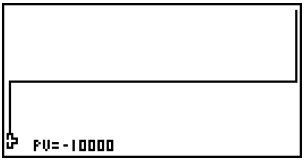
- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function keys to maneuver between calculation result screens.

- F1(REPT) ..... Parameter input screen
- F4(AMT) .... Amortization screen
- F6(GRPH) .... Draws graph



After drawing a graph, you can press F1(TRACE) to turn on trace and read calculation results along the graph.



Press ESC to turn off trace.

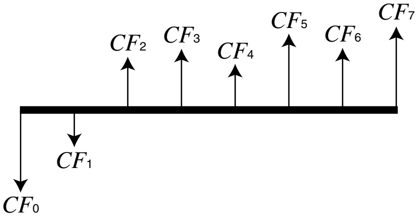
Press ESC again to return to the parameter input screen.

2-4 Cash Flow (Investment Appraisal)

This calculator uses the discounted cash flow (DCF) method to perform investment appraisal by totalling cash flow for a fixed period. This calculator can perform the following four types of investment appraisal.

- Net present value (NPV)
- Net future value (NFV)
- Internal rate of return (IRR)
- Pay back period (PBP)

A cash flow diagram like the one shown below helps to visualize the movement of funds.



With this graph, the initial investment amount is represented by CF_0. The cash flow one year later is shown by CF_1, two years later by CF_2, and so on.

Investment appraisal can be used to clearly determine whether an investment is realizing profits that were originally targeted.

•NPV

$$NPV = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \ldots + \frac{CF_n}{(1+i)^n} \qquad \left(i = \frac{I\%}{100}\right)$$

n: natural number up to 254

•NFV

$$NFV = NPV \times (1 + i)^n$$

•IRR

$$0 = CF_0 + \frac{CF_1}{(1+i)} + \frac{CF_2}{(1+i)^2} + \frac{CF_3}{(1+i)^3} + \ldots + \frac{CF_n}{(1+i)^n}$$

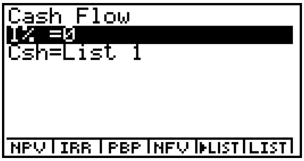
In this formula, $NPV = 0$, and the value of IRR is equivalent to $i \times 100$. It should be noted, however, that minute fractional values tend to accumulate during the subsequent calculations performed automatically by the calculator, so NPV never actually reaches exactly zero. IRR becomes more accurate the closer that NPV approaches to zero.

•*PBP*

PBP is the value of *n* when *NPV* ≧ 0 (when investment can be recovered).

- Press F3(CASH) from the Financial 1 screen to display the following input screen for Cash Flow.

F3(CASH)


Cash Flow
I% =0
Csh=List 1

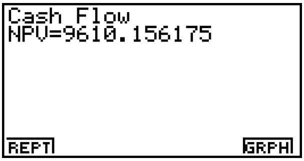
I% .... interest rate (%)

Csh .... list for cash flow

If you have not yet input data into a list, press F5(▶LIST) and input data into a list.

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

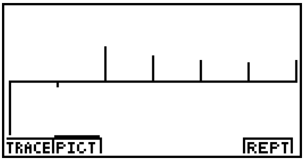
- F1(NPV) .... Net present value
- F2(IRR) .... Internal rate of return
- F3(PBP) .... Pay back period
- F4(NFV) .... Net future value
- F5(▶LIST) ..... Inputs data from a list
- F6(LIST) .... Specifies a list for data input


Cash Flow
NPV=9610.156175

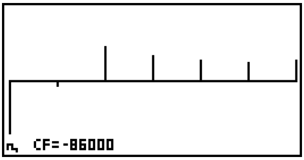
- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function keys to maneuver between calculation result screens.

- F1(REPT)...... Parameter input screen
- F6(GRPH) ..... Draws graph



After drawing a graph, you can press F1(TRACE) to turn on trace and read calculation results along the graph.



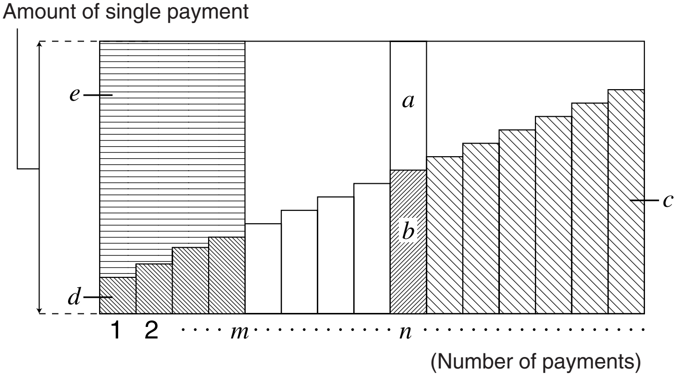
Press ESC to turn off trace.

Press ESC again to return to the parameter input screen.

2-5 Amortization

This calculator can be used to calculate the principal and interest portion of a monthly installment, the remaining principal, and amount of principal and interest repaid up to any point.

•Formula



a: interest portion of installment PM1 (INT)

b: principal portion of installment PM1 (PRN)

c: balance of principal after installment PM2 (BAL)

d: total principal from installment PM1 to payment of installment PM2 (ΣPRN)

e: total interest from installment PM1 to payment of installment PM2 (ΣINT)

*$a + b$ = one repayment (PMT)

$$a : INT_{PM1} = | BAL_{PM1-1} \times i | \times (PMT \text{ sign})$$

$$b : PRN_{PM1} = PMT + BAL_{PM1-1} \times i$$

$$c : BAL_{PM2} = BAL_{PM2-1} + PRN_{PM2}$$

$$d : \sum_{PM1}^{PM2} PRN = PRN_{PM1} + PRN_{PM1+1} + \ldots + PRN_{PM2}$$

$$e : \sum_{PM1}^{PM2} INT = INT_{PM1} + INT_{PM1+1} + \ldots + INT_{PM2}$$

$BAL_0 = PV$ ($INT_1 = 0$ and $PRN_1 = PMT$ at beginning of installment term)

•Converting between the nominal interest rate and effective interest rate

The nominal interest rate ($I\%$ value input by user) is converted to an effective interest rate ($I\%'$) for installment loans where the number of installments per year is different from the number of compound interest calculation periods.

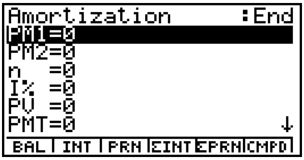
$$I\%' = \left\{ \left(1 + \frac{I\%}{100 \times [C/Y]}\right)^{\frac{[C/Y]}{[P/Y]}} - 1 \right\} \times 100$$

The following calculation is performed after conversion from the nominal interest rate to the effective interest rate, and the result is used for all subsequent calculations.

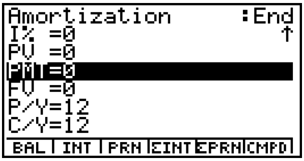
$$i = I\%' \div 100$$

Press F4(AMT) from the Financial 1 screen to display the following input screen for interest rate conversion.

F4(AMT)



```
Amortization     :End
PM1=0
PM2=0
n  =0
I% =0
PV =0
PMT=0                ↓
```

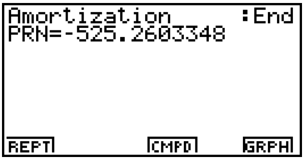


```
Amortization     :End
I% =0                ↑
PV =0
PMT=0
FV =0
P/Y=12
C/Y=12
```

PM1	first installment of installments 1 through n
PM2	second installment of installments 1 through n
n	installments
$I\%$	interest rate
PV	principal
PMT	payment for each installment
FV	balance following final installment
P/Y	installments per year
C/Y	compoundings per year

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

- F1(BAL) .... Balance of principal after installment PM2
- F2(INT) .... Interest portion of installment PM1
- F3(PRN) .... Principal portion of installment PM1
- F4(Σ INT) .... Total interest paid from installment PM1 to installment PM2
- F5(Σ PRN) ...... Total principal paid from installment PM1 to installment PM2
- F6(CMPD) ...... Compound interest screen

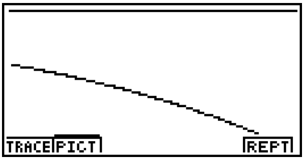


```
Amortization     :End
PRN=-525.2603348
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

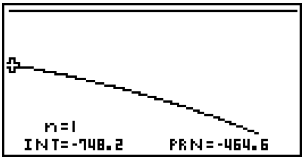
Use the following function keys to maneuver between calculation result screens.

- F1(REPT) .... Parameter input screen
- F4(CMPD) ...... Compound interest screen
- F6(GRPH) ...... Draws graph



After drawing a graph, you can press F1(TRACE) to turn on trace and read calculation results along the graph.

The first press of F1(TRACE) displays INT and PRN when n = 1. Each press of ▶ shows INT and PRN when n = 2, n = 3, and so on.



```
n=1
INT=-748.2     PRN=-464.6
```

Press ESC to turn off trace.

Press ESC again to return to the parameter input screen.

2-6 Interest Rate Conversion

The procedures in this section describe how to convert between the annual percentage rate and effective interest rate.

●Formula

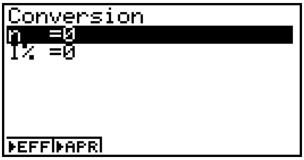
$$EFF = \left[\left(1 + \frac{APR/100}{n}\right)^{n} - 1\right] \times 100$$

$$APR = \left[\left(1 + \frac{EFF}{100}\right)^{\frac{1}{n}} - 1\right] \times n \times 100$$

APR : annual percentage rate (%)
EFF : effective interest rate (%)
n : number of compoundings

Press F5(CNVT) in the Financial 1 screen to display the following input screen for interest rate conversion.

F5(CNVT)

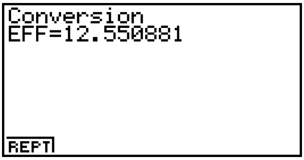


```
Conversion
n  =0
I% =0
```

n .... number of compoundings
I% .... interest rate

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

- F1(▶EFF) ... Converts annual percent rate to effective interest rate
- F2(▶APR) ... Converts effective interest rate to annual percent rate



```
Conversion
EFF=12.550881
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function key to maneuver between calculation result screens.

- F1(REPT) ... Parameter input screen

2-7 Cost, Selling Price, Margin

Cost, selling price, or margin can be calculated by inputting the other two values.

•Formula

$$CST = SEL\left(1-\frac{MRG}{100}\right)$$

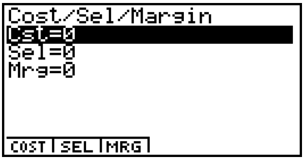
$$SEL = \frac{CST}{1-\dfrac{MRG}{100}}$$

$$MRG(\%) = \left(1-\frac{CST}{SEL}\right)\times 100$$

CST : cost
SEL : selling price
MRG : margin

Press F1 (COST) from the Financial 2 screen to display the following input screen.

F6 (▷) F1 (COST)



Cost/Sel/Margin
Cst=0
Sel=0
Mrg=0

Cst	cost
Sel	selling price
Mrg	margin

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

- F1 (COST) .... Cost
- F2 (SEL) .... Selling price
- F3 (MRG) ...... Margin

Cost/Sel/Margin
Cst=1700

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function key to maneuver between calculation result screens.

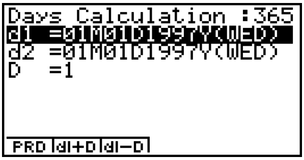
- F1 (REPT) ... Parameter input screen

2-8 Day/Date Calculations

You can calculate the number of days between two dates, or you can determine what date comes a specific number of days before or after another date.

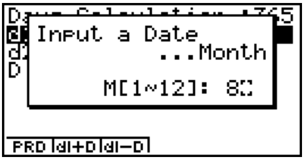
Press F2(DAYS) from the Financial 2 screen to display the following input screen for day/date calculation.

F6(▷)F2(DAYS)


Days Calculation :365
d1 =01M01D1997Y(WED)
d2 =01M01D1997Y(WED)
D =1

d1	date 1
d2	date 2
D	number of days

To input a date, first highlight d1 or d2. Pressing a number key to input the month causes an input screen like the one shown below to appear on the display.


Input a Date
...Month
M[1~12]: 8

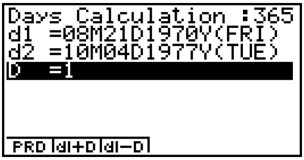
The set up screen can be used to specify either a 365-day or 360-day year for financial calculations. Day/date calculations are also performed in accordance with the current setting for number of days in the year, but the following calculations cannot be performed when the 360-day year is set. Attempting to do so causes an error.

(Date) + (Number of Days)

(Date) – (Number of Days)

The allowable calculation range is January 1, 1901 to December 31, 2099.

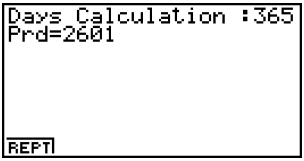
Input the month, day, and year, pressing EXE after each.



```
Days Calculation :365
d1 =08M21D1970Y(FRI)
d2 =10M04D1977Y(TUE)
D  =1
```

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

- F1 (PRD) .... Number of days from d1 to d2 (d2 – d1)
- F2 (d1+D) .... d1 plus a number of days (d1 + D)
- F3 (d1 – D) ..... d1 minus a number of days (d1 – D)



```
Days Calculation :365
Prd=2601
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function key to maneuver between calculation result screens.

- F1 (REPT) ...... Parameter input screen

360-day Date Mode Calculations

The following describes how calculations are processed when 360 is specified for the Date Mode item in the SET UP screen.

- If d1 is day 31 of a month, d1 is treated as day 30 of that month is used.
- If d2 is day 31 of a month, d2 is treated as day 1 of the following month, unless d1 is day 30.

2-9 Depreciation

Any of the following four methods can be used to calculated depreciation.

•Straight-Line Method

The straight-line method calculates depreciation for a given period.

$$SL_1 = \frac{(PV-FV)}{n} \bullet \frac{\{Y-1\}}{12}$$

$$SL_j = \frac{(PV-FV)}{n}$$

$$SL_{n+1} = \frac{(PV-FV)}{n} \bullet \frac{12-\{Y-1\}}{12}$$

$$(\{Y-1\} \neq 12)$$

SL_j : depreciation charge for the jth year
n : useful life in years
PV : original cost (basis)
FV : scrap value (salvage value)
j : year
$Y-1$: number of depreciable months in first year

Depreciation for an item acquired part way through a year can be calculated by month.

•Fixed Percentage Method

Fixed percentage method can be used to calculate depreciation for a given period, or to calculate the depreciation rate.

$$FP_1 = PV \times \frac{I\%}{100} \times \frac{\{Y-1\}}{12}$$

$$FP_j = (RDV_{j-1} + FV) \times \frac{I\%}{100}$$

$$FP_{n+1} = RDV_n \quad (\{Y-1\} \neq 12)$$

$$RDV_1 = PV - FV - FP_1$$

$$RDV_j = RDV_{j-1} - FP_j$$

$$RDV_{n+1} = 0 \quad (\{Y-1\} \neq 12)$$

FP_j : depreciation charge for the jth year
RDV_j : remaining depreciable value at the end of jth year
$I\%$: depreciation rate

Depreciation for an item acquired part way through a year can be calculated by month.

•Sum-of-the-Year's Digits Method

The sum-of-the-year's-digits method calculates depreciation for a given period.

$$Z = \frac{n\,(n+1)}{2}$$

$$n' = n - \frac{\{Y-1\}}{12}$$

$$Z' = \frac{(n'\text{ integer part }+1)(n'\text{ integer part } + 2{*}n'\text{ fraction part})}{2}$$

$$SYD_1 = \frac{n}{Z} \times \frac{\{Y-1\}}{12}\,(PV - FV)$$

$$SYD_j = \left(\frac{n' - j + 2}{Z'}\right)(PV - FV - SYD_1) \qquad (j \neq 1)$$

$$SYD_{n+1} = \left(\frac{n' - (n+1) + 2}{Z'}\right)(PV - FV - SYD_1) \times \frac{12 - \{Y-1\}}{12} \qquad (\{Y-1\} \neq 12)$$

$$RDV_1 = PV - FV - SYD_1$$

$$RDV_j = RDV_{j-1} - SYD_j$$

SYD_j : depreciation charge for the jth year

RDV_j : remaining depreciable value at the end of jth year

Depreciation for an item acquired part way through a year can be calculated by month.

•Declining Balance Method

The declining balance method calculates depreciation for a given period.

$$DB_1 = PV \times \frac{I\%}{100n} \times \frac{Y-1}{12}$$

$$RDV_1 = PV - FV - DB_1$$

$$DB_j = (RDV_{j-1} + FV) \times \frac{I\%}{100n}$$

$$RDV_j = RDV_{j-1} - DB_j$$

$$DB_{n+1} = RDV_n \qquad (\{Y-1\} \neq 12)$$

$$RDV_{n+1} = 0 \qquad (\{Y-1\} \neq 12)$$

DB_j : depreciation charge for the jth year

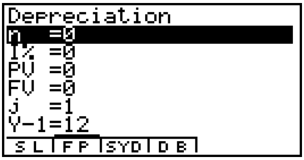
RDV_j : remaining depreciable value at the end of jth year

$I\%$: factor (%)

Depreciation for an item acquired part way through a year can be calculated by month.

Press F3(DEPR) from the Financial 2 screen to display the following input screen for depreciation.

F6(▷) F3(DEPR)



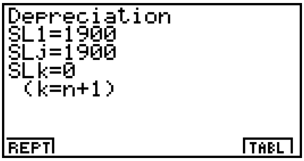
Depreciation
n =0
I% =0
PV =0
FV =0
j =1
Y-1=12

n	useful life in years
I%	depreciation rate/factor
PV	original cost (basis)
FV	scrap value (salvage value)
j	year
Y–1	number of depreciable months in first year

- Parameters can be displayed as integer or decimal values only. Inputting a fraction causes it to be converted to a decimal value.

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

- F1(SL) .... Straight-Line Method
- F2(FP) .... 1.Fixed Percentage Method
  .... 2.Depreciation ratio
- F3(SYD) .... Sum-of-the-Year's Digits Method
- F4(DB) .... Declining Balance Method

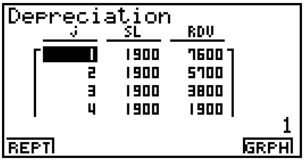


Depreciation
SL1=1900
SLj=1900
SLk=0
(k=n+1)

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function keys to maneuver between calculation result screens.

- F1 (REPT) ...... Parameter input screen
- F6 (TABL) .... Calculation result table



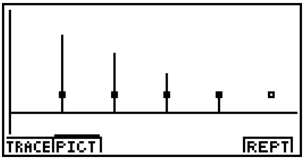
Depreciation

j	SL	RDV
1	1900	7600
2	1900	5700
3	1900	3800
4	1900	1900

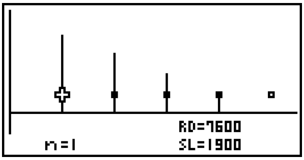
1

The following function keys are on the calculation result table screen.

- F1 (REPT) ...... Parameter input screen
- F6 (GRPH) ..... Draws graph



After drawing a graph, you can press F1 (TRACE) to turn on trace and read calculation results along the graph.



RD=7600
n=1
SL=1900

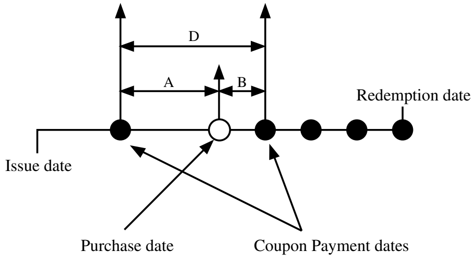
Press ESC to turn off trace.

Press ESC again to return to the parameter input screen.

2-10 Bonds

The bond calculation function calculates the price and yield of a bond.

•Formula



PRC : price per $100 of face value
CPN : annual coupon rate (%)
YLD : yield to maturity (%)
A : accrued days
M : number of coupon payments per year (1=annual, 2=semi annual)
N : number of coupon payments between settlement date and maturity date
RDV : redemption price or call price per $100 of face value
D : number of days in coupon period where settlement occurs
B : number of days from settlement date until next coupon payment date = D – A
INT : accrued interest
CST : price including interest

- Less than six months to redemption

$$PRC = \frac{RDV + \frac{CPN}{M}}{1+ \left(\frac{B}{D} \times \frac{YLD/100}{M} \right)} - \left(\frac{A}{D} \times \frac{CPN}{M} \right)$$

- Six months or more to redemption

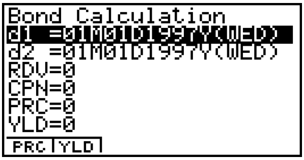
$$PRC = \frac{RDV}{\left(1+ \frac{YLD/100}{M}\right)^{(N-1+B/D)}} + \sum_{k=1}^{N} \frac{\frac{CPN}{M}}{\left(1+ \frac{YLD/100}{M}\right)^{(K-1+B/D)}} - \frac{A}{D} \times \frac{CPN}{M}$$

$$INT = \frac{A}{D} \times \frac{CPN}{M}$$

$$CST = PRC + INT$$

Press F4(BOND) from the Financial 2 screen to display the following input screen for band calculation.

F6(▷)F4(BOND)



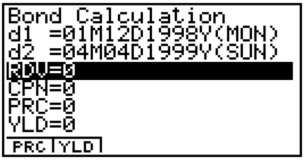
```
Bond Calculation
d1 =01M01D1997Y(WED)
d2 =01M01D1997Y(WED)
RDV=0
CPN=0
PRC=0
YLD=0
```

d1	purchase date
d2	redemption date
RDV	redemption price or call price per $100 of face value
CPN	annual coupon rate (%)
PRC	price per $100 of face value
YLD	yield to maturity (%)

To input a date, first highlight d1 or d2. Pressing a number key to input the month causes an input screen like the one shown below to appear on the display.

```
Input a Date
     ...Month

   M[1~12]: 1
YLD=0
```

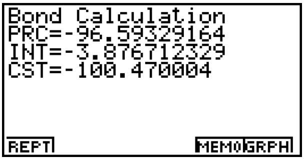
Input the month, day, and year, pressing EXE after each.



```
Bond Calculation
d1 =01M12D1998Y(MON)
d2 =04M04D1999Y(SUN)
RDV=0
CPN=0
PRC=0
YLD=0
```

After configuring the parameters, press one of the function keys noted below to perform the corresponding calculation.

- F1(PRC) ..... Price per $100 of face value
- F2(YLD) ..... Yield to maturity



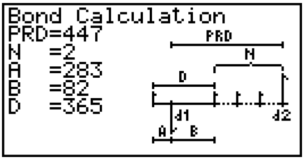
```
Bond Calculation
PRC=-96.59329164
INT=-3.876712329
CST=-100.470004
```

- An error (Ma ERROR) occurs if parameters are not configured correctly.

Use the following function keys to maneuver between calculation result screens.

- F1(REPT) .... Parameter input screen
- F5(MEMO) ..... Screen of various bond calculation values*
- F6(GRPH) ...... Draws Graph

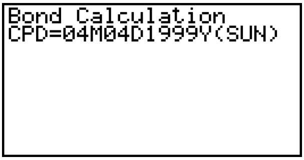
Pressing F5(MEMO) displays various bond calculation values, like those shown here.



Bond Calculation
PRD=447
N =2
A =283
B =82
D =365

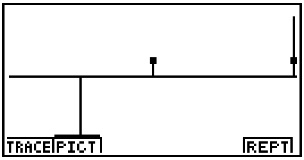
*The interest payment date is calculated from d2 when 365 is specified for the Date Mode item in the SET UP screen.

EXE ~ EXE

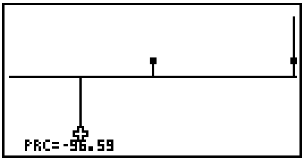


Bond Calculation
CPD=04M04D1999Y(SUN)

F6(GRPH)



After drawing a graph, you can press F1(TRACE) to turn on trace and read calculation results along the graph.



PRC=-96.59

Press ESC to turn off trace.

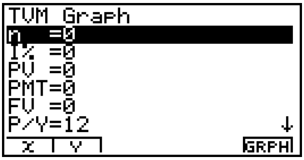
Press ESC again to return to the parameter input screen.

2-11 TVM Graph

The TVM Graph lets you assign two of the five parameters (*n*, *I*%, *PV*, *PMT*, *FV*) to the *x*-axis and *y*-axis of a graph, and plot changes in *y* as the value of *x* changes.

Press F5(TVMG) from the Financial 2 screen to display the following input screen for TVM Graph.

F6(▷)F5(TVMG)



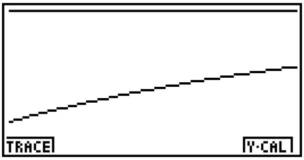
```
TVM Graph
n   =0
I%  =0
PV  =0
PMT=0
FV  =0
P/Y=12                ↓
```

After configuring the parameters, press the function keys noted below to assign parameters to the *x*-axis and *y*-axis.

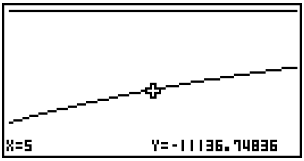
- F1(X) ... Assigns highlighted parameter to the *x*-axis
- F2(Y) ... Assigns highlighted parameter to the *y*-axis

After making the required settings, draw the graph.

- F6(GRPH) ... Draws graph



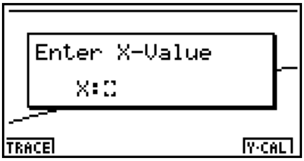
After drawing a graph, you can press F1(TRACE) to turn on trace and read calculation results along the graph.



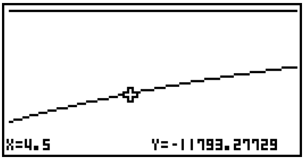
```
X=5                Y=-11136.74836
```

Press ESC to turn off trace.

Pressing F6 (Y-CAL) after drawing a graph displays the screen shown below.


Enter X-Value
X:

Inputting an x-axis value on this screen and pressing EXE displays the corresponding y-axis value.



Press ESC again to return to the parameter input screen.

- Calculation may take some time to perform when you specify I% as the y-axis parameter.

Chapter 3

Differential Equations

This chapter explains how to solve the four types of differential equations listed below.

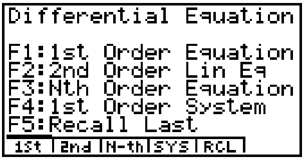
- Differential equations of the first order
- Linear differential equations of the second order
- Differential equations of the Nth order
- System of first order differential equations

3-1 Using the DIFF EQ Mode

You can solve differential equations numerically and graph the solutions. The general procedure for solving a differential equation is described below.

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.



Differential Equation

F1:1st Order Equation
F2:2nd Order Lin Eq
F3:Nth Order Equation
F4:1st Order System
F5:Recall Last

Execution

2. Select the differential equation type.
   - F1 (1st) .... Four types of first order differential equations
   - F2 (2nd) ...... Second order linear differential equations
   - F3 (N-th) ...... Differential equations of the first order through ninth order
   - F4 (SYS) ..... System of the first order differential equations
   - F5 (RCL) ..... Displays a screen for recalling a previous differential equation.
   - With F1 (1st), you need to make further selections of differential equation type. See "Differential equations of the first order" for more information.
   - With F3 (N-th), you also need to specify the order of the differential equation, from 1 to 9.
   - With F4 (SYS), you also need to specify the number of unknowns, from 1 to 9.
3. Enter the differential equation.
4. Specify the initial values.
5. Press F5 (SET) and select 1 (Param) to display the Parameter screen. Specify the calculation range. Make the parameter settings you want.
   - h.................. Step size for the classical Runge-Kutta method (fourth order)
   - Step .... Number of steps for graphing[*1] and storing data in LIST.
   - SF .... The number of slope field columns displayed on the screen (0 – 100). The slope fields can be displayed only for differential equations of the first order.

[*1] When graphed for the first time, a function is always graphed with every step. When the function is graphed again, however, it is graphed according to a value of Step. For example, when Step is set to 2, the function is graphed with every two steps.

6. Specify variables to graph or to store in LIST.
   Press F5(SET) and select 2(Output) to display the list setting screen.
   x, y, $y^{(1)}$, $y^{(2)}$, ..., $y^{(8)}$ stand for the independent variable, the dependent variable, the first order derivative, the second order derivative, ..., and the eighth order derivative, respectively.
   1st, 2nd, 3rd, ..., 9th stand for the initial values in order.
   To specify a variable to graph, select it using the cursor keys (▲, ▼) and press F1(SEL).
   To specify a variable to store in LIST, select it using the cursor keys (▲, ▼) and press F2(LIST).
7. Press SHIFT OPTN(V-Window) to display the V-Window setting screen. Before you solve a differential equation, you need to make V-Window settings.

   Xmin … x-axis minimum value

   max … x-axis maximum value

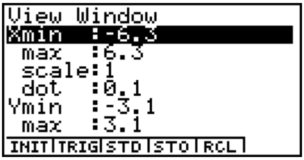
   scale … x-axis value spacing

   dot … value corresponding to one x-axis dot

   Ymin … y-axis minimum value

   max … y-axis maximum value

   scale … y-axis value spacing



```
View Window
Xmin  :-6.3
 max  :6.3
 scale:1
 dot  :0.1
Ymin  :-3.1
 max  :3.1
```

8. Press F6(CALC) to solve the differential equation.
   - The calculated result is graphed or stored in the list.

Only the slope fields are displayed if you do not input initial values or if you input the wrong type of initial values.

An error occurs if you set SF to zero and you do not input the initial values, or if you input the initial values inappropriately.

You are advised to input parentheses and a multiplication sign between a value and an expression in order to prevent calculation errors.

Do not confuse the − key and the (−) key. A syntax error occurs if you use the (−) key as the subtraction symbol.

An error occurs if you input variable y in the function $f(x)$. Variable x is treated as a variable. Other variables (A through Z, r, θ, excluding X and Y) are treated as constants and the value currently assigned to that variable is applied during the calculation.

An error occurs if you input variable x in the function $g(y)$. Variable y is treated as a variable. Other variables (A through Z, r, θ, excluding X and Y) are treated as constants and the value currently assigned to that variable is applied during the calculation.

3-2 Differential Equations of the First Order

Separable Equation

Description

To solve a separable equation, simply input the equation and specify the initial values.

$$dy/dx = f(x)g(y)$$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F1 (1st) to display the menu of first order differential equations, and then select 1 (Separ).
3. Specify $f(x)$ and $g(y)$.
4. Specify the initial value for x_0, y_0.
5. Press F5 (SET) 1 (Param).
6. Specify the calculation range.
7. Specify the step size for h.
8. Press F5 (SET) 2 (Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
9. Make V-Window settings.
10. Press F6 (CALC) to solve the differential equation.

• • • • •

Example **To graph the solutions of the separable equation $dy/dx = y^2 - 1$, $x_0 = 0$, $y_0 = \{0, 1\}$, $-5 \leqq x \leqq 5$, $h = 0.1$.**

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DIFF EQ

② F1 (1st) 1 (Separ)

③ 1 EXE

ALPHA − (Y) ∧ 2 − 1 EXE

④ 0 EXE

SHIFT × ({) 0 , 1 SHIFT ÷ (}) EXE

⑤ F5 (SET) 1 (Param)

⑥ (−) 5 EXE

5 EXE

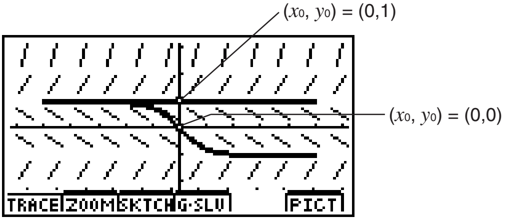
⑦ 0 . 1 EXE ESC

⑧ F5 (SET) 2 (Output) F4 (INIT) ESC

⑨ SHIFT OPTN (V-Window) F1 (INIT) ESC

⑩ F6 (CALC)

Result Screen



$(x_0, y_0) = (0,1)$

$(x_0, y_0) = (0,0)$

To graph a family of solutions, enter a list of initial conditions.

Linear Equation

To solve a linear equation, simply input the equation and specify initial values.

$$dy/dx + f(x)y = g(x)$$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F1(1st) to display the menu of differential equations of the first order, and then select 2(Linear).
3. Specify $f(x)$ and $g(x)$.
4. Specify the initial value for x_0, y_0.
5. Press F5(SET)1(Param).
6. Specify the calculation range.
7. Specify the step size for h.
8. Press F5(SET)2(Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
9. Make V-Window settings.
10. Press F6(CALC) to solve the differential equation.

• • • • •

Example **To graph the solution of the linear equation $dy/dx + xy = x$, $x_0 = 0$, $y_0 = -2$, $-5 \leqq x \leqq 5$, $h = 0.1$.**

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DIFF EQ

② F1 (1st) 2 (Linear)

③ X,θ,T EXE
X,θ,T EXE

④ 0 EXE
(–) 2 EXE

⑤ F5 (SET) 1 (Param)

⑥ (–) 5 EXE
5 EXE

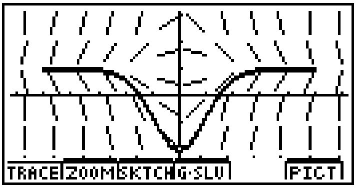
⑦ 0 • 1 EXE ESC

⑧ F5 (SET) 2 (Output) F4 (INIT) ESC

⑨ SHIFT OPTN (V-Window) F1 (INIT) ESC

⑩ F6 (CALC)

Result Screen



Bernoulli equation

To solve a Bernoulli equation, simply input the equation and specify the power of y and the initial values.

$$dy/dx + f(x)y = g(x)y^n$$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F1(1st) to display the menu of differential equations of the first order, and then select 3(Bern).
3. Specify $f(x)$, $g(x)$, and n.
4. Specify the initial value for x_0, y_0.
5. Press F5(SET)1(Param).
6. Specify the calculation range.
7. Specify the step size for h.
8. Press F5(SET)2(Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
9. Make V-Window settings.
10. Press F6(CALC) to solve the differential equation.

• • • • •

Example **To graph the solution of the Bernoulli equation $dy/dx - 2y = -y^2$, $x_0 = 0$, $y_0 = 1$, $-5 \leqq x \leqq 5$, $h = 0.1$.**

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DIFF EQ

② F1(1st) 3(Bern)

③ (–) 2 EXE
(–) 1 EXE
2 EXE

④ 0 EXE
1 EXE

⑤ F5(SET) 1(Param)

⑥ (–) 5 EXE
5 EXE

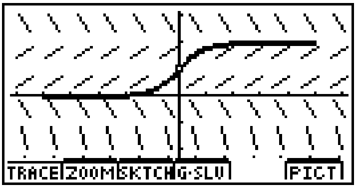
⑦ 0 • 1 EXE ESC

⑧ F5(SET) 2(Output) F4(INIT) ESC

⑨ SHIFT OPTN(V-Window) F1(INIT) ESC

⑩ F6(CALC)

Result Screen



Others

To solve a general differential equation of the first order, simply input the equation and specify the initial values. Use the same procedures as those described above for typical differential equations of the first order.

$$dy/dx = f(x, y)$$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F1(1st) to display the menu of differential equations of the first order, and then select 4(Others).
3. Specify $f(x, y)$.
4. Specify the initial value for x_0, y_0.
5. Press F5(SET)1(Param).
6. Specify the calculation range.
7. Specify the step size for h.
8. Press F5(SET)2(Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
9. Make V-Window settings.
10. Press F6(CALC) to solve the differential equation.

● ● ● ● ●

Example **To graph the solution of the first order differential equation $dy/dx = -\cos x$, $x_0 = 0$, $y_0 = 1$, $-5 \leqq x \leqq 5$, $h = 0.1$.**

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DIFF EQ

② F1 (1st) 4 (Others)

③ (–) cos X,θ,T EXE

④ 0 EXE

1 EXE

⑤ F5 (SET) 1 (Param)

⑥ (–) 5 EXE

5 EXE

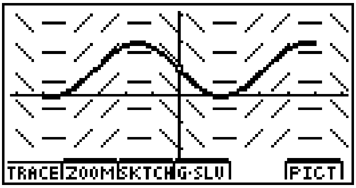
⑦ 0 • 1 EXE ESC

⑧ F5 (SET) 2 (Output) F4 (INIT) ESC

⑨ SHIFT OPTN (V-Window) F1 (INIT) ESC

⑩ F6 (CALC)

Result Screen



3-3 Linear Differential Equations of the Second Order

Description

To solve a linear differential equation of the second order, simply input the equation and specify the initial values. Slope fields are not displayed for a linear differential equation of the second order.

$$y'' + f(x)\ y' + g(x)y = h(x)$$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F2(2nd).
3. Specify $f(x)$, $g(x)$, and $h(x)$.
4. Specify the initial value for x_0, y_0, y'_0.
5. Press F5(SET)1(Param).
6. Specify the calculation range.
7. Specify the step size for h.
8. Press F5(SET)2(Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
9. Make V-Window settings.
10. Press F6(CALC) to solve the differential equation.

● ● ● ● ●

Example **To graph the solution of the linear differential equation of the second order $y'' + 9y = \sin 3x$, $x_0 = 0$, $y_0 = 1$, $y'_0 = 1$, $0 \leqq x \leqq 10$, $h = 0.1$.**

Use the following V-Window settings.

Xmin = –1, Xmax = 11, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1

Procedure

① MENU DIFF EQ

② F2 (2nd)

③ 0 EXE
9 EXE
sin 3 X,θ,T EXE

④ 0 EXE
1 EXE
1 EXE

⑤ F5 (SET) 1 (Param)

⑥ 0 EXE
1 0 EXE

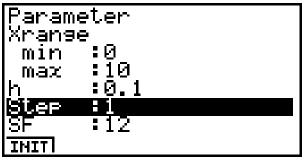
⑦ 0 • 1 EXE *1 ESC

⑧ F5 (SET) 2 (Output) F4 (INIT) ESC

⑨ SHIFT OPTN (V-Window)
(–) 1 EXE
1 1 EXE
1 EXE ▼
(–) 3 • 1 EXE
3 • 1 EXE
1 EXE *2 ESC

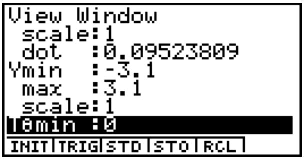
⑩ F6 (CALC)

*1



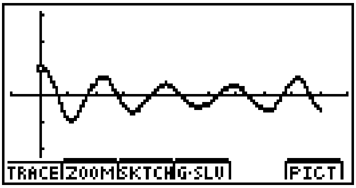
```
Parameter
Xrange
 min  :0
 max  :10
h     :0.1
Step  :1
SF    :12
INIT
```

*2



```
View Window
 scale:1
 dot  :0.09523809
Ymin  :-3.1
 max  :3.1
 scale:1
θmin  :0
INIT TRIG STD STO RCL
```

Result Screen



3-4 Differential Equations of the Nth Order

You can solve differential equations of the first through ninth order. The number of initial values required to solve the differential equation depends on its order.

- Enter dependent variables y, y', y'', $y^{(3)}$, ..., $y^{(9)}$ as follows.

y	ALPHA − (Y)
y'	F3 ($y(n)$) 1 (Y1)
y''	F3 ($y(n)$) 2 (Y2)
$y^{(3)}(=y''')$	F3 ($y(n)$) 3 (Y3)
	⋮
$y^{(8)}$	F3 ($y(n)$) 8 (Y8)
$y^{(9)}$	F3 ($y(n)$) 9 (Y9)

■ Differential Equation of the Fourth Order

The following example shows how to solve a differential equation of the fourth order.

$$y^{(4)} = f(x, y, ... , y^{(3)})$$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F3 (N-th).
3. Press F3 (n) 4 to select a differential equation of the fourth order.
4. Specify $y^{(4)}$.
5. Specify the initial value for x_0, y_0, y'_0, y''_0, and $y^{(3)}_0$.
6. Press F5 (SET) 1 (Param).
7. Specify the calculation range.
8. Specify the step size for h.
9. Press F5 (SET) 2 (Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
10. Make V-Window settings.
11. Press F6 (CALC) to solve the differential equation.

● ● ● ● ●

Example **To graph the solution of the differential equation of the fourth order below**

$y^{(4)} = 0$, $x_0 = 0$, $y_0 = 0$, $y'_0 = -2$, $y''_0 = 0$, $y^{(3)}_0 = 3$, $-5 \leqq x \leqq 5$, $h = 0.1$.

Use the following V-Window settings.

Xmin = –6.3, Xmax = 6.3, Xscale = 1

Ymin = –3.1, Ymax = 3.1, Yscale = 1 (initial defaults)

Procedure

① MENU DIFF EQ

② F3 (N-th)

③ F3 (n) 4 EXE

④ 0 EXE

⑤ 0 EXE
0 EXE
(–) 2 EXE
0 EXE
3 EXE

⑥ F5 (SET) 1 (Param)

⑦ (–) 5 EXE
5 EXE

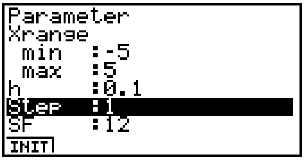
⑧ 0 • 1 EXE [*1] ESC

⑨ F5 (SET) 2 (Output) F4 (INIT) ESC

⑩ SHIFT OPTN (V-Window) F1 (INIT) ESC

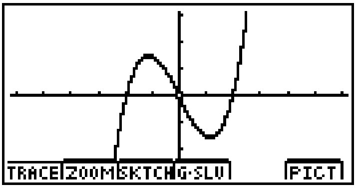
⑪ F6 (CALC)

[*1]



```
Parameter
Xrange
 min   :-5
 max   :5
h      :0.1
Step   :1
SF     :12
INIT
```

Result Screen



Converting a High-order Differential Equation to a System of First Order Differential Equations

You can convert a single N-th order differential equation to a system of n first order differential equations.

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution (N = 3)

2. Press F3 (N-th).
3. Press F3 (n) 3 to select a differential equation of the third order.
4. Perform substitutions as follows.

   y' → Y1 (F3 ($y_{(n)}$) 1)

   y'' → Y2 (F3 ($y_{(n)}$) 2)
5. Specify the initial value for x_0, y_0, y'_0, and y''_0.
6. Press F2 (→SYS).
7. Press EXE (Yes).

- The entered differential equation is converted to a system of three first order differential equations. Initial values are also converted accordingly.

● ● ● ● ●

Example **Express the differential equation below as a set of first order differential equations.**
$y^{(3)} = \sin x - y' - y'', x_0 = 0, y_0 = 0, y'_0 = 1, y''_0 = 0.$

Procedure

① MENU DIFF EQ

② F3 (N-th)

③ F3 (n) 3 EXE

④ sin X,θ,T − F3 ($y_{(n)}$) 1 − F3 ($y_{(n)}$) 2 EXE

⑤ 0 EXE
0 EXE
1 EXE
0 EXE

⑥ F2 (→SYS)

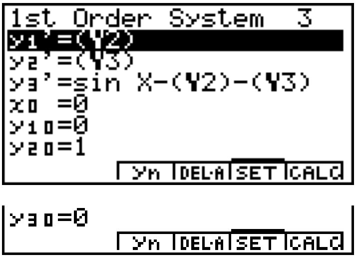
⑦ EXE (Yes)

The differential equation is converted to a set of first order differential equations as shown below.

$(y_1)' = dy/dx = (y_2)$
$(y_2)' = d^2y/dx^2 = (y_3)$
$(y_3)' = \sin x - (y_2) - (y_3).$

Initial values are also converted to $(x_0 = 0)$, $((y_1)_0 = 0)$, $((y_2)_0 = 1)$, and $((y_3)_0 = 0)$).

Result Screen



```
1st Order System   3
y1'=(Y2)
y2'=(Y3)
y3'=sin X-(Y2)-(Y3)
x0  =0
y10=0
y20=1
```

```
y30=0
```

On the system of first order differential equations screen, dependent valuables are expressed as follows.

$(y_1) \rightarrow (Y1)$
$(y_2) \rightarrow (Y2)$
$(y_3) \rightarrow (Y3)$

3-5 System of First Order Differential Equations

A system of first order differential equations, for example, has dependent variables (y_1), (y_2), ..., and (y_9), and independent variable x. The example below shows a system of first order differential equations.

$(y_1)' = (y_2)$

$(y_2)' = -(y_1) + \sin x$

Set Up

1. From the Main Menu, enter the DIFF EQ Mode.

Execution

2. Press F4(SYS).
3. Enter the number of unknowns.
4. Enter the expression as shown below.
   $(y_1) \rightarrow$ Y1 (F3(y_n) 1)
   $(y_2) \rightarrow$ Y2 (F3(y_n) 2)
   ⋮
   $(y_9) \rightarrow$ Y9 (F3(y_n) 9)
5. Specify the initial value for x_0, $(y_1)_0$, $(y_2)_0$ and so on, if necessary.
6. Press F5(SET) 1(Param).
7. Specify the calculation range.
8. Specify the step size for h.
9. Press F5(SET) 2(Output).
   Select the variable you want to graph, and then select a list for storage of the calculation results.
10. Make V-Window settings.
11. Press F6(CALC) to solve the system of first order equations for y_1, y_2, and so on.

• • • • •

Example 1 **To graph the solution of first order differential equations with two unknowns below.**

$(y_1)' = (y_2)$, $(y_2)' = -(y_1) + \sin x$, $x_0 = 0$, $(y_1)_0 = 1$, $(y_2)_0 = 0.1$, $-2 \leqq x \leqq 5$, $h = 0.1$.

Use the following V-Window settings.

Xmin = –3, Xmax = 6, Xscale = 1

Ymin = –2, Ymax = 2, Yscale = 1

Procedure

① MENU DIFF EQ

② F4(SYS)

③ F2(2)

④ F3(yn) 2 EXE

(–) F3(yn) 1 + sin X,θ,T EXE

⑤ 0 EXE

1 EXE

0 • 1 EXE

⑥ F5(SET) 1(Param)

⑦ (–) 2 EXE

5 EXE

⑧ 0 • 1 EXE *1 ESC

⑨ F5(SET) 2(Output) F4(INIT)

▼ ▼ F1(SEL)

(Select (y_1) and (y_2) to graph)*2

ESC

⑩ SHIFT OPTN(V-Window)

(–) 3 EXE

6 EXE

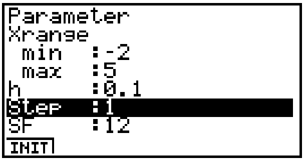
1 EXE ▼

(–) 2 EXE

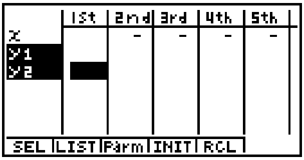
2 EXE

1 EXE ESC

⑪ F6(CALC)

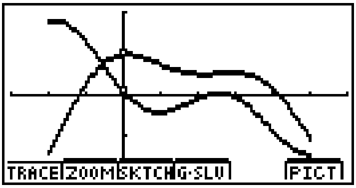
*1 

```
Parameter
Xrange
 min   :-2
 max   :5
h      :0.1
Step   :1
SF     :12
INIT
```

*2 

```
   |1st |2nd |3rd |4th |5th
x  |    | -  | -  | -  | -
y1 |
y2 |
SEL LIST Parm INIT RCL
```

Result Screen



● ● ● ● ●

Example 2 **To graph the solution of the system of first order differential equations below.**

$(y_1)' = (2 - (y_2))\ (y_1)$

$(y_2)' = (2\ (y_1) - 3)\ (y_2)$

$x_0 = 0,\ (y_1)_0 = 1,\ (y_2)_0 = 1/4,\ 0 \leqq x \leqq 10,\ h = 0.1.$

Use the following V-Window settings.

Xmin = –1, Xmax = 11, Xscale = 1

Ymin = –1, Ymax = 8, Yscale = 1

Procedure

① MENU DIFF EQ

② F4 (SYS)

③ F2 (2)

④ (2 − F3 (yn) 2) × F3 (yn)

1 EXE

(2 × F3 (yn) 1 − 3

) × F3 (yn) 2 EXE

⑤ 0 EXE

1 EXE

1 ÷ 4 EXE

⑥ F5 (SET) 1 (Param)

⑦ 0 EXE

1 0 EXE

⑧ 0 . 1 EXE *1 ESC

⑨ F5 (SET) 2 (Output) F4 (INIT)

▼ ▼ F1 (SEL)

(Select (y_1) and (y_2) to graph.)

▲ ▲ F2 (LIST) 1 EXE (Select LIST1 to store the values for x in LIST1)

▼ F2 (LIST) 2 EXE (Select LIST2 to store the values for (y_1) in LIST2)

▼ F2 (LIST) 3 EXE (Select LIST3 to store the values for (y_2) in LIST3)*2

ESC

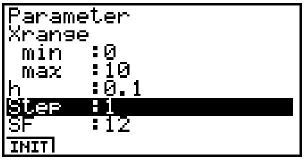
⑩ SHIFT OPTN (V-Window)

(−) 1 EXE 1 1 EXE 1 EXE ▼

(−) 1 EXE 8 EXE 1 EXE ESC

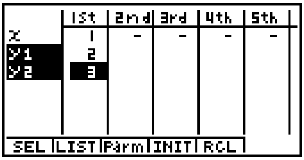
⑪ F6 (CALC)

*1



```
Parameter
Xrange
 min   :0
 max   :10
h      :0.1
Step   :1
SF     :12
INIT
```

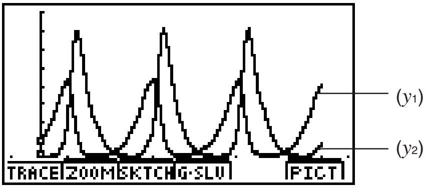
*2



	1st	2nd	3rd	4th	5th
x	1	-	-	-	-
y1	2				
y2	3				

SEL LIST Parm INIT RCL

Result Screen



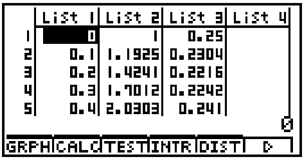
Further Analysis

To further analyze the result, we can graph the relation between (y_1) and (y_2).

Procedure

① MENU STAT

② List 1, List 2, and List 3 contain values for x, (y_1), and (y_2), respectively.



	List 1	List 2	List 3	List 4
1	0	1	0.25	
2	0.1	1.1925	0.2304	
3	0.2	1.4241	0.2216	
4	0.3	1.7012	0.2242	
5	0.4	2.0303	0.241	

0

③ F1 (GRPH) 5 (Set)

④ F1 (GPH1)

⑤ ▼ F2 (xy)

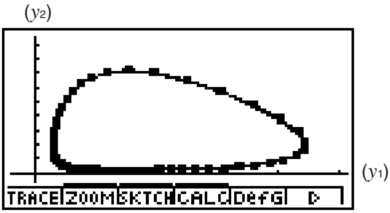
⑥ ▼ F1 (LIST) 2 EXE (XLIST = LIST2: (y_1))

⑦ ▼ F1 (LIST) 3 EXE (YLIST = LIST3: (y_2))

ESC

⑧ F1 (GRPH) 1 (S-Gph1)

Result Screen



Important!

- This calculator may abort calculation part way through when an overflow occurs part way through the calculation when calculated solutions cause the solution curve to extend into a discontinuous region, when a calculated value is clearly false, etc.
- The following steps are recommended when the calculator aborts a calculation as described above.
  1. If you are able to determine beforehand the point where the solution curve overflows, stop the calculation before the point is reached.
  2. If you are able to determine beforehand the point where the solution curve extends into a discontinuous region, stop the calculation before the point is reached.
  3. In other cases, reduce the size of the calculation range and the value of h (step size) and try again.
  4. When you need to perform a calculation using a very wide calculation range, store intermediate results in a list and perform a new calculation starting from step 3 using the stored results as initial values. You can repeat this step multiple times, if necessary.

■ SET UP Items

G-Mem {G-Mem 20}/{1 – 20} ...... Specifies a memory location {G-Mem No.} for storage of the latest graph functions.

Note the following regarding SET UP screen settings whenever using the DIFF EQ Mode.

The DIFF EQ Mode temporarily stores data into Graph Memory whenever a differential equation calculation is performed. Before the calculation, DIFF EQ stores the latest graph functions into the currently specified Graph Memory (G-Mem) location. After the calculation, it recalls the graph functions from the specified G-Mem location, without deleting the G-Mem data. Because of this, you should specify the G-Mem location (number) where the DIFF EQ Mode stores the graph functions.

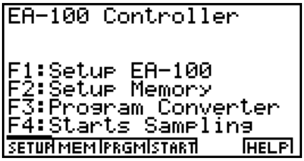
Chapter 4

E-CON

All of the explanations provided here assume that you are already familiar with the operating precautions, terminology, and operational procedures of the calculator and the EA-100.

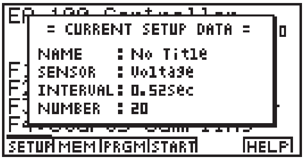
4-1 E-CON Overview

- From the Main Menu, select E-CON to enter the E-CON Mode.



```
EA-100 Controller

F1:Setup EA-100
F2:Setup Memory
F3:Program Converter
F4:Starts Sampling
```

- The E-CON provides the functions listed below for simple and more efficient data sampling using the CASIO EA-100.
  - F1 (SETUP) ... Displays a screen for setting up the EA-100.
  - F2 (MEM) .... Displays a screen for saving EA-100 setup data under a file name.
  - F3 (PRGM) ..... Performs program conversion.
    - This function converts EA-100 setup data created by E-CON to a program.
    - It can also be used to convert data to a program that can be run on a CFX-9850 Series/fx-7400 Series calculator, and to transfer the data to the calculator.
  - F4 (START) .... Starts data collection.
  - F6 (HELP) ...... Displays E-CON help.
- Pressing the OPTN key (Setup Preview) or a cursor key while the E-CON main menu is on the screen displays a preview dialog box that shows the contents of the setup in the current setup memory area.



```
= CURRENT SETUP DATA =
NAME    : No Title
SENSOR  : Voltage
INTERVAL: 0.52Sec
NUMBER  : 20
```

To close the preview dialog box, press ESC.

About online help

Pressing the F6 (HELP) key displays online help about the E-CON Mode.

4-2 EA-100 Setup

You can use the E-CON Mode to set up the EA-100 for sampling and then start sampling immediately or save the setup in calculator memory. You can use either of the following two methods to set up the EA-100.

Setup Wizard:	With this method, you set up the EA-100 simply by replying to questions as they appear.
Advanced Setup:	Advanced setup gives you control over a variety of sampling parameters, which means you can set up the EA-100 for exactly the type of sampling you want.

■ Using Setup Wizard to Create an EA-100 Setup

With Setup Wizard, you set up the EA-100 simply by replying to questions as they appear.

• Setup Wizard parameters

Setup Wizard lets you make changes to the following three EA-100 basic sampling parameters using an interactive wizard format.

- Sensor (Select Sensor)
  Specify a CASIO or VERNIER[*1] sensor from a menu of choices.
- Sampling Interval (Sampling Time)
  When you have Photogate specified as the sensor type, you can specify the sampling timing (Gate Status) and sampling time recording method (Record Time) with this parameter.
- Number of Samples (Number of Samples)
  You can specify a value from 1 to 255.

Note the following limitations that apply to a setup made using Setup Wizard.

- You can use Setup Wizard only when the EA-100 sampling channel is CH1 or SONIC.
- The trigger for a Setup Wizard setup is always the EXE key.
- Sampling results are always stored in List 1 (for the sampling time) and List 2 (for sample values).

[*1] Vernier Software & Technology

• To create an EA-100 setup using Setup Wizard

Before getting started...

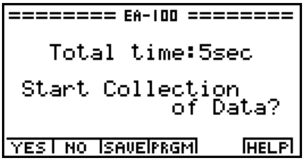
- Before starting the procedure below, make sure you first decide if you want to start sampling immediately using the setup you create with Setup Wizard, or if you want to store the setup for later sampling.
- See sections 4-3, 4-4, and 4-5 of this manual for information about procedures required to start sampling and to store a setup. We recommend that you read through the entire procedure first, referencing the other sections and pages as noted, before actually trying to perform it.
- To terminate Setup Wizard part way through and cancel the setup, press SHIFT ESC (QUIT).

1. Display the E-CON main menu.
2. Press F1 (SETUP). This displays the “Setup EA-100” sub-menu.
3. Press 1 (Wizard). This displays the Setup Wizard initial screen.

```
========= EA-100 =========

    Setup Wizard
          for BEGINNER

    Press any key
```

4. Press any key to start Setup Wizard and display the sensor specification screen.
   - Press F1 to specify a CASIO sensor, or F2 to specify a VERNIER sensor. From the menu of supported sensors that appears, select the one you want.
5. The screen that appears after you select a sensor in step 4 depends on whether or not you specified “Photogate” as the sensor.
   - If you did not specify “Photogate,” a screen for setting the sampling interval appears after step 4.
     1. Use the number keys to input the sampling interval.
        - Inputting a value in the range of 0.52 to 300 enables real-time sampling. Inputting a value outside this range enables non-real-time sampling.
     2. Press EXE.
   - If you specified “Photogate” as the sensor, a screen for setting the sampling timing appears after step 4.
     1. Press either F1 (Open) or F2 (Close) to specify the sampling timing. Pressing either key advances to a screen for setting the time recording method.
        - See online help (GATE TRIGGER STATUS HELP) for details about the Open and Close settings.
     2. Press F1 (Abs) or F2 (Rel) to specify the sampling time recording method.

6. After you complete step 5, a screen for setting the number of samples appears on the display.
   - Use the number keys to input the number of samples, and then press EXE.
7. After you complete step 6, a screen like the one shown below appears on the display.



======== EA-100 ========

Total time:5sec

Start Collection of Data?

- Press one of the function keys described below to specify what you want to do with the setup you have created with the above steps.
  - F1(YES) .... Starts sampling using the setup (page 4-5-1).
  - F2(NO) .... Returns to the E-CON main menu (page 4-1-1).
  - F3(SAVE) ...... Saves the setup (page 4-3-1).
  - F4(PRGM) ..... Converts the setup to a program (page 4-4-1).
- Pressing F2(NO) in step 7 returns to the E-CON main menu and stores the setup in the E-CON Mode's current setup memory area. You can use the following function key operations from the E-CON main menu to manipulate the contents of the current setup memory area.
  - F2(MEM), then F2(SAVE)
    .... Saves the current setup memory area setup (page 4-3-1).
  - F3(PRGM) ..... Converts the setup in the current setup memory area to a program (page 4-4-1).
  - F4(START) .... Starts sampling using the setup in the current setup memory area (page 4-5-1).
- Pressing F1(SETUP) and then 2(Advan) displays an Advanced Setup screen for more detailed control over the parameters that make up the setup in the current setup memory area. See "Creating an EA-100 Setup Using Advanced Setup" for more information about changing advanced setup parameters.

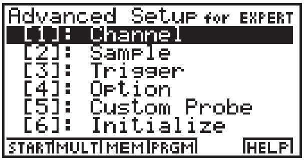
■ Creating an EA-100 Setup Using Advanced Setup

Advanced Setup provides you with total control over a number of parameters that you can adjust to create the EA-100 setup that suits your particular needs.

• To create an EA-100 setup using Advanced Setup

The following procedure describes the general steps for using Advanced Setup. Refer to the pages as noted for more information.

1. Display the E-CON main menu.
2. Press F1(SETUP). This displays the “Setup EA-100” sub-menu.
3. Press 2(Advan). This displays the Advanced Setup menu.



Advanced Setup for EXPERT
[1]: Channel
[2]: Sample
[3]: Trigger
[4]: Option
[5]: Custom Probe
[6]: Initialize

4. If you want to configure a custom probe at this point, press 5(Custom Probe). Next, follow the steps under “To configure a custom probe starting from the Advanced Setup menu” on page 4-2-12.
   - You can also configure a custom probe during the procedure under “To change Channel parameter settings” on page 4-2-6.
   - Custom probe configurations you have stored in memory can be selected using Channel in step 5, below.
5. Use the Advanced Setup function keys described below to set other parameters.
   - 1(Channel) .... Displays a screen for setting the following parameters: sampling channel, sensor, sensor configuration, and storage location for sample data (page 4-2-5).
   - 2(Sample) ..... Displays a screen for setting the following parameters: real-time settings, sampling interval, number of samples, measurement time recording method, and storage location for measurement time records (page 4-2-7).
   - 3(Trigger) ...... Displays a screen for setting sampling start (trigger) conditions (page 4-2-8).
   - 4(Option) .... Displays a screen for making View Window settings, real-time settings (channel for real-time sampling), and filter settings (page 4-2-10).

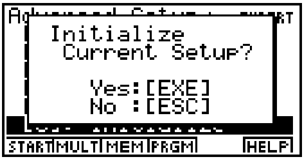
- You can return the settings on the above setup screens (1 through 4) using the procedure described under “To return setup parameters to their initial defaults”.

6. After you create a setup, you can use the function key operations described below to start sampling or perform other operations.
    - F1(START) .... Starts sampling using the setup (page 4-5-1).
    - F2(MULT) ...... Starts MULTIMETER Mode sampling using the setup (page 4-2-14).
    - F3(MEM) .... Saves the setup (page 4-3-1).
    - F4(PRGM) ..... Converts the setup to a program (page 4-4-1).

• To return setup parameters to their initial defaults

Perform the following procedure when you want to return the parameters of the setup in the current setup memory area to their initial defaults.

1. While the Advanced Setup menu is on the display, press 6(Initialize).



Initialize
Current Setup?

Yes:[EXE]
No :[ESC]

2. In response to the confirmation message that appears, press EXE to initialize the setup.
    - To clear the confirmation message without initializing the setup, press ESC.

• Advanced setup parameters

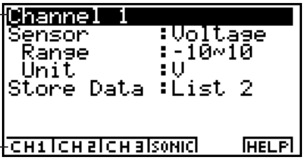
This section provides detailed information about the parameters you can change in step 5 of the procedure under “To create an EA-100 setup using Advanced Setup” on page 4-2-4.

Channel

Selecting this parameter displays a screen where you can specify the EA-100 channel to be used for sampling, the type of sensor used for each channel, and the storage location for saving sample data.

• To change Channel parameter settings

1. While the Advanced Setup menu is on the display, press 1 (Channel).
   - This displays the Channel parameter setting screen.



```
Channel 1
Sensor       :Voltage
 Range       :-10~10
 Unit        :V
Store Data   :List 2
```

Selected item

Current setting of selected item

2. Use the function key operations described below to change Channel parameter settings.
   (1) Selected Channel
   - F1 (CH1) .... Channel 1
   - F2 (CH2) .... Channel 2
   - F3 (CH3) .... Channel 3
   - F4 (SONIC) .... Sonic channel

   (2) Selected Sensor (Sensor)
   - F1 (CASIO) .... CASIO sensor
   - F2 (VERN) ..... VERNIER sensor
   - F3 (CSTM) ..... Custom probe
   - F4 (None) .... No sensor

   (3) Sample Data Storage Location (Store Data)
   - F1 (LIST) .... Displays a dialog box for specifying the list for storage of measurement data. Specify a list number from 1 to 20.

   - To change the setting of an item, first use the ▲ and ▼ cursor keys to move the highlighting to the item. Next, use the function keys to select the setting you want. Note that the Channel parameter settings you make affect the Selected Channel only. You need to make separate settings for each channel you plan to use for sampling.
   - Specifying a sensor causes its sampling range (Range) and measurement unit (Unit) to appear on the display.

3. After all the settings are the way you want, press EXE to return to the Advanced Setup menu.

If the list you specify for the Sample Data Storage Location (Store Data) in step 2 is already being used, data is overwritten according to the priority sequence shown below.

1. (Highest) SONIC
2. CH3
3. CH2
4. CH1
5. (Lowest) Record Time

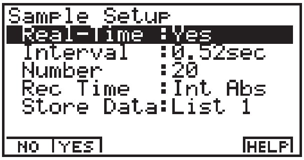
Example: Specifying the same list number for CH3 sample data and SONIC sample data causes the CH3 data to be overwritten by the SONIC data.

Sample

Selecting this parameter displays a screen for making real-time settings, and for specifying the sampling interval, number of samples, measurement time recording method, and storage location for measurement time records.

• To change Sample Setup settings

1. While the Advanced Setup menu is on the display, press 2(Sample).
   - This displays the Sample Setup screen.



```
Sample Setup
 Real-Time :Yes
 Interval  :0.52sec
 Number    :20
 Rec Time  :Int Abs
 Store Data:List 1

 NO  YES                HELP
```

2. Use the function key operations described below to change Sample Setup settings.
   - To change the setting of an item, first use the ▲ and ▼ cursor keys to move the highlighting to the item. Next, use the function keys to select the setting you want.

   (1) Real-time Settings (Real-Time)
   - F1(NO) .... Disables real-time sampling.
   - F2(YES) .... Enables real-time sampling.

   (2) Sampling Interval (Interval)
   - F1(TIMER) .... Displays a dialog box for specifying a timer value, and enables fixed-interval sampling.
   - F2(KEY) .... Starts sampling operation that uses the EA-100 [TRIGGER] key. The [TRIGGER] key must be pressed the number of times specified for the number of samples.
   - F3(GATE) ...... Starts sampling in accordance with the Photogate Gate Status trigger timing. Press F1, F2, or F3 to specify the channel of the Photogate sensor. Photogate is assigned to the sensor of the specified channel.

   (3) Number of Samples (Number)
   - F1(NUM) .... Displays a dialog box for specifying the number of samples by inputting a value from 1 to 255.

(4) Measurement Time Recording Method (Rec Time)

- F1(None) .... No time recorded.
- F2(Abs) .... Absolute time in seconds from start of sampling
- F3(Rel) .... Relative time (interval between samples) in seconds
- F4(Int A) .... Absolute time calculated from sampling interval and number of samples
- F5(Int R) .... Relative time calculated from sampling interval and number of samples

(5) Sample Data Storage Location (Store Data)

- F1(LIST) .... Displays a dialog box for specifying the list (1 to 20) for storing sample data.

3. After all the settings are the way you want, press EXE to return to the Advanced Setup menu.

Trigger

Use the Trigger Setup screen to specify the following measurement start (trigger) conditions: trigger source, trigger threshold, trigger edge.

• To change Trigger Setup settings

1. While the Advanced Setup menu is on the display, press 3(Trigger).
   - This displays the Trigger Setup screen.


Trigger Setup
Source :[EXE]key

Selected item

Current setting of selected item

2. Use the function key operations described below to change Trigger Setup settings.
   - To change the setting of an item, first use the ▲ and ▼ cursor keys to move the highlighting to the item. Next, use the function keys to select the setting you want.

   (1) Trigger Source (Source)
   - F1(KEY)
     - 1([EXE]) .... Calculator EXE key press starts sampling.
     - 2(TRIGER) ...... EA-100 [TRIGGER] key press starts sampling.
   - F2(CH1) .... Channel 1
   - F3(CH2) .... Channel 2
   - F4(CH3) .... Channel 3
   - Specifying CH1, CH2, or CH3 as the trigger source displays the specified channel's sensor name, trigger threshold initial value, measurement unit, and trigger edge initial value.

   (2) Trigger Threshold (Threshold)
   - F1(EDIT) .... Displays a dialog box for inputting the trigger threshold. This option is available only when CH1, CH2, or CH3 is specified as the trigger source.

   (3) Trigger Edge (Edge)
   - F1(Rise) .... Rising edge triggers sampling
   - F2(Fall) .... Falling edge triggers sampling

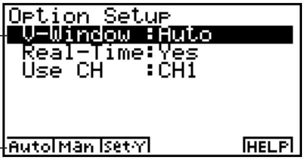
3. After all the settings are the way you want, press EXE to return to the Advanced Setup menu.

Option

Use the Option Setup screen to make View Window settings, to specify the channel for real-time sampling, and to make filter settings.

• To change Option Setup settings

1. While the Advanced Setup menu is on the display, press 4 (Option).
   - This displays the Option Setup screen.



Option Setup
V-Window :Auto
Real-Time:Yes
Use CH :CH1

Selected item

Current setting of selected item

2. Use the function key operations described below to change Option Setup settings.
   - To change the setting of an item, first use the ▲ and ▼ cursor keys to move the highlighting to the item. Next, use the function keys to select the setting you want.

   (1) View Window Settings (V-Window)
   - F1 (Auto) .... Makes View Window settings automatically.
   - F2 (Man) .... Enables manual View Window settings.
   - F3 (Set•Y) ...... Displays screens for specifying the Y-axis (sample data) minimum value (Ymin) and maximum value (Ymax).

   (2) Real-time Settings (Real-Time)
   - F1 (NO) .... Disables real-time sampling.
   - F2 (YES) .... Enables real-time sampling.
   - Note that this item is linked with the Real-Time item of the Sample Setup on page 4-2-7.

(3) Real-time Sampling Channel (Use CH)

- F1(CH1) .... Channel 1
- F2(CH2) .... Channel 2
- F3(CH3) .... Channel 3
- F4(SONIC) .... Sonic channel
- Note that the above options appear only when real-time sampling is turned on (by pressing F1(YES) for the Real-Time item).

(4) Filter Settings (Filter)

- F1(None) .... No setting
- F2(S-G) .... S-G Smoothing
  - 1(5-p): 5-point
  - 2(9-p): 9-point
  - 3(17-p): 17-point
  - 4(25-p): 25-point
- F3(MED) .... Median Filter
  - 1(3-p): 3-point
  - 2(5-p): 5-point
- Note that the above options appear only when real-time sampling is turned off (by pressing F2(NO) for the Real-Time item).

3. After all the settings are the way you want, press EXE to return to the Advanced Setup menu.

• To configure a custom probe

You can use the procedures in this section to configure a custom probe[*1] for use with the EA-100.

Creating a New Custom Probe Configuration

To configure a custom probe, you must input values for the constants of the fixed linear transformation formula ($ax + b$). The required constants are slope (a) and intercept (b).
x in the above expression ($ax + b$) is the sampled voltage value (sampling range: 0 to 5 volts).
You can use either of the two following procedures to create a new custom probe configuration while creating an EA-100 setup using Advanced Setup.

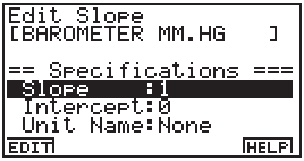
[*1] The term "custom probe" means any sensor other than the CASIO or VERNIER sensors specified as standard for the E-CON Mode.

• To configure a custom probe starting from the Advanced Setup menu

1. From the E-CON main menu, press F1(SETUP) and then 2(Advan) to display the Advanced Setup menu.
   - See "Creating an EA-100 Setup Using Advanced Setup" on page 4-2-4 for more information.
2. On the Advanced Setup menu, press 5(Custom Probe) to display the Custom Probe List.

Custom Probe List
1:BAROMETER MM.HG
2:BAROMETER MBAR
3:EKG

   - The message "No Custom Probe" appears if the Custom Probe List is empty.
3. Press F2(NEW).
   - This displays the screen for inputting the name of the new custom probe.
4. Input up to 18 characters for the custom probe name, and then press EXE.
   - This displays the screen for configuring a new custom probe.



Edit Slope
[BAROMETER MM.HG]
== Specifications ===
Slope :1
Intercept:0
Unit Name:None

5. Use the function key operations described below to make custom probe configuration settings.
   - To change the setting of an item, first use the ▲ and ▼ cursor keys to move the highlighting to the item. Next, use the function keys to select the setting you want.

   (1) Slope
   Press F1(EDIT) to display a dialog box for inputting the slope for the linear transformation formula.

   (2) Intercept
   Press F1(EDIT) to display a dialog box for inputting the intercept for the linear transformation formula.

   (3) Unit Name
   Press F1(EDIT) to display a dialog box for inputting up to eight characters for the unit name.

6. Press EXE and then input a memory number (1 to 99).
   - This saves the custom probe configuration and returns to the Custom Probe List, which should now contain the new custom probe you configured.

• To configure a custom probe starting from the Channel parameter setting screen

1. From the E-CON main menu, press F1(SETUP) and then 2(Advan) to display the Advanced Setup menu.
   - See "Creating an EA-100 Setup Using Advanced Setup" on page 4-2-4 for more information.
2. On the Advanced Setup menu, press 1(Channel).
3. On the Channel parameter setting screen, press the function key (F1, F2, or F3) for the channel whose parameter settings you want to change.
4. Next press ▼ F3(CSTM) to display the Custom Probe List.
5. Perform steps 3 through 6 under "To configure a custom probe starting from the Advanced Setup menu" on page 4-2-12.

Editing an Existing Custom Probe Configuration

Use the following procedure when you want to edit the configuration of an existing custom probe.

1. Display the Custom Probe List.
2. Select the custom probe whose configuration you want to edit.
   - Use the ▲ and ▼ cursor keys to highlight the name of the custom probe you want.
3. Press F3(EDIT).
   - This displays the screen for configuring a custom probe.
   - To edit the custom probe settings, perform the procedure starting from step 5 under "To configure a custom probe starting from the Advanced Setup menu" on page 4-2-12.

Deleting a Custom Probe Configuration

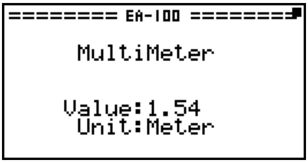
Use the following procedure when you want to delete the configuration of a custom probe.

1. Display the Custom Probe List.
2. Select the custom probe whose configuration you want to delete.
   - Use the ▲ and ▼ cursor keys to highlight the name of the custom probe you want.
3. Press F4(DEL).
4. In response to the confirmation message that appears, press EXE to delete the custom probe configuration.
   - To clear the confirmation message without deleting anything, press ESC.

• To use the MULTIMETER Mode

You can use the Channel parameter settings of Advanced Setup to configure a channel so that EA-100 MULTIMETER Mode sampling is triggered by a calculator operation.

1. Use the Channel parameter setting Sensor item to configure a sensor.
   - See "To create an EA-100 setup using Advanced Setup" on page 4-2-4 for more information.
2. After making the required settings, press EXE to display the Advanced Setup menu and then press F2 (MULT).
   - This displays the channel selection screen for MULTIMETER Mode sampling.
3. Specify a channel for sampling.
   - Pressing a function key to specify a channel causes the EA-100 to enter the MULTIMETER Mode and start sampling over the specified channel.



```
======== EA-100 ========
MultiMeter

Value:1.54
 Unit:Meter
```

4. To stop MULTIMETER Mode sampling, first press the AC key. After the Break screen appears, press ESC.
   - Sample data is updated at intervals of 0.52 second.
   - Do not have sensors connected to channels other than the one you specify in step 3. However, it is not necessary to specify "None" for the Channel parameter Sensor item for the unused channels.
   - Sample data is not stored in memory.

4-3 Setup Memory

You can use setup memory to save EA-100 setups you create using Setup Wizard or Advanced Setup in calculator memory for later recall when you need them.

Saving a Setup

A setup can be saved when any one of the following conditions exist.

- After creating a new setup with Setup Wizard
  See step 7 under "To create an EA-100 setup using Setup Wizard" on page 4-2-2.
- After creating a new setup with Advanced Setup
  See step 6 under "To create an EA-100 setup using Advanced Setup" on page 4-2-4 for more information.
- While the E-CON main menu is on the display
  Performing the setup save operation while the E-CON main menu is on the display saves the contents of the current setup memory area (which were created using Setup Wizard or Advanced Setup).

Details on saving a setup are listed below.

• To save a setup

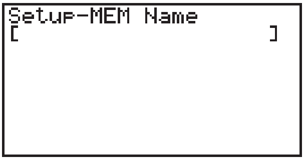
1. Start the save operation by performing one of the function key operations described below.
   - If the final Setup Wizard screen is on the display, press F3 (SAVE).
   - If the Advanced Setup menu screen is on the display, press F3 (MEM).
   - If the E-CON main menu screen is on the display, press F2 (MEM).

   - Performing any one of the above operations causes the setup memory list to appear.

```
Setup-MEM List
 1:TEMP BARO 1WEEK
 2:REALTIME MOTION
 3:HEARTBEAT
```

   - The message "No Setup-MEM" appears if setup memory is empty.

2. Press F2(SAVE).
   - This displays the screen for inputting the setup name.



Setup-MEM Name
[ ]

3. Press EXE and then input a memory number (1 to 99).
   - If you start from the final setup screen, this saves the setup and the message "Complete!" appears. Press EXE to return to the final setup screen.
   - If you start from the Advanced Setup menu or the E-CON main menu, this saves the setup and returns to the setup memory list which includes the name you assigned it.

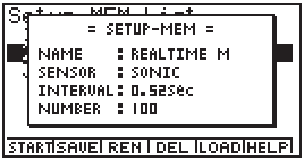
■ Using and Managing Setups in Setup Memory

All of the setups you save are shown in the setup memory list. After selecting a setup in the list, you can use it to sample data or you can edit it.

• To preview saved setup data

You can use the following procedure to check the contents of a setup before you use it for sampling.

1. On the E-CON main menu, press F2(MEM) to display the setup memory list.
2. Use the ▲ and ▼ cursor keys to highlight the name of the setup you want.
3. Press OPTN(Setup Preview).
   - This displays the preview dialog box.



= SETUP-MEM =
NAME : REALTIME M
SENSOR : SONIC
INTERVAL: 0.52Sec
NUMBER : 100

4. To close the preview dialog box, press ESC.

• To recall a setup and use it for sampling

Be sure to perform the following steps before starting sampling with the EA-100.

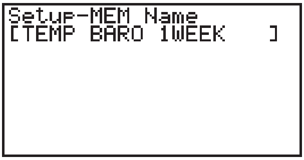
1. Connect the calculator to the EA-100.
2. Turn on EA-100 power.
3. In accordance with the setup you plan to use, connect the proper sensor to the appropriate EA-100 channel.
4. Prepare the item whose data is to be sampled.

• To recall a setup and use it for sampling

1. On the E-CON main menu, press F2(MEM) to display the setup memory list.
2. Use the ▲ and ▼ cursor keys to highlight the name of the setup you want.
3. Press F1(START).
4. In response to the confirmation message that appears, press EXE.
   - Pressing EXE sets up the EA-100 and then starts sampling.
   - To clear the confirmation message without sampling, press ESC.

• To change the name of setup data

1. On the E-CON main menu, press F2(MEM) to display the setup memory list.
2. Use the ▲ and ▼ cursor keys to highlight the name of the setup you want.
3. Press F3(REN).
   - This displays the screen for inputting the setup name.



```
Setup-MEM Name
[TEMP BARO 1WEEK    ]
```

4. Input up to 18 characters for the setup name, and then press EXE.
   - This changes the setup name and returns to the setup memory list.

See “Operations during a sampling operation” on page 4-5-2 for information about operations you can perform while a sampling operation is in progress.

• To delete setup data

1. On the E-CON main menu, press F2(MEM) to display the setup memory list.
2. Use the ▲ and ▼ cursor keys to highlight the name of the setup you want.
3. Press F4(DEL).
4. In response to the confirmation message that appears, press EXE to delete the setup.
   - To clear the confirmation message without deleting anything, press ESC.

• To recall setup data

Recalling setup data stores it in the current setup memory area. You can then use Advanced Setup to edit the setup. This capability comes in handy when you need to perform a setup that is slightly different from one you have stored in memory.

1. On the E-CON main menu, press F2(MEM) to display the setup memory list.
2. Use the ▲ and ▼ cursor keys to highlight the name of the setup you want.
3. Press F5(LOAD).
4. In response to the confirmation message that appears, press EXE to recall the setup.
   - To clear the confirmation message without recalling the setup, press ESC.

Recalling setup data replaces any other data currently in the current setup memory area.

4-4 Program Converter

Program Converter converts an EA-100 setup you created using Setup Wizard or Advanced Setup to a program that can run on the calculator. You can also use Program Converter to convert a setup to a CFX-9850 Series/fx-7400 Series-compatible program and transfer it to a calculator.[*1] [*2]

Converting a Setup to a Program

A setup can be converted to a program when any one of the following conditions exists.

- After creating a new setup with Setup Wizard
  See step 7 under "To create an EA-100 setup using Setup Wizard" on page 4-2-2.
- After creating a new setup with Advanced Setup
  See step 6 under "To create an EA-100 setup using Advanced Setup" on page 4-2-4 for more information.
- While the E-CON main menu is on the display
  Performing the program converter operation while the E-CON main menu is on the display converts the contents of the current setup memory area (which were created using Setup Wizard or Advanced Setup).

The program converter procedure is identical in all of the above cases.

• To convert a setup to a program

1. Start the converter operation by performing one of the function key operations described below.
   - If the final Setup Wizard screen is on the display, press F4(PRGM).
   - If the Advanced Setup menu screen is on the display, press F4(PRGM).
   - If the E-CON main menu screen is on the display, press F3(PRGM).

   - This displays the program name input screen.

Input Program Name
[   ]

F1:Transmit Program
    to CFX-9850/7400

2. Input the name you want to assign to the program.

[*1] See the documentation that came with your scientific calculator or EA-100 for information about how to use a converted program.

[*2] See online help (PROGRAM CONVERTER HELP) for information about supported CFX-9850 Series and fx-7400 Series models.

3. Press EXE.
   - This starts conversion of the setup data to a program.
   - The message “Complete!” appears when conversion is complete.

• To convert setup data to a program and transfer it to a CFX-9850 Series/ fx-7400 Series calculator

1. Connect the scientific calculator (CFX-9850 Series or fx-7400 Series) to the ALGEBRA calculator.
   - Perform the necessary procedure on the scientific calculator to set it up to receive data.
2. Perform steps 1 and 2 of the procedure under “To convert a setup to a program” on page 4-4-1.
3. Press F1 (TRNS). On the sub-menu that appears, specify the type of scientific calculator (1: FX9850 or 2: fx7400) for which you want to create a program.
   - Program conversion and transfer starts as soon as you specify a calculator model.
   - The message “Complete!” appears when conversion is complete.

When you convent setup data to a CFX-9850 Series or fx-7400 Series program, any sample value storage list number greater than 5 is changed to 5.

CFX-9850 Series or fx-7400 Series calculators support up to six lists only.

List 6 is used for EA-100 setup.

4-5 Starting a Sampling Operation

The section describes how to use a setup created using the E-CON Mode to start an EA-100 sampling operation.

Before getting started...

Be sure to perform the following steps before starting sampling with the EA-100.

1. Connect the calculator to the EA-100.
2. Turn on EA-100 power.
3. In accordance with the setup you plan to use, connect the proper sensor to the appropriate EA-100 channel.
4. Prepare the item whose data is to be sampled.

Starting a Sampling Operation

A sampling operation can be started when any one of the following conditions exist.

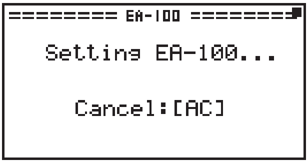
- After creating a new setup with Setup Wizard
  See step 7 under “To create an EA-100 setup using Setup Wizard” on page 4-2-2.
- After creating a new setup with Advanced Setup
  See step 6 under “To create an EA-100 setup using Advanced Setup” on page 4-2-4.
- While the E-CON main menu is on the display
  Starting a sampling operation while the E-CON main menu is on the display performs sampling using the contents of the current setup memory area (which were created using Setup Wizard or Advanced Setup).
- While the setup memory list is on the display
  You can select the setup you want on the setup memory list and then start sampling.

The following procedures explain the first three conditions described above. See “To recall a setup and use it for sampling” on page 4-3-3 for information about starting sampling from the setup memory list.

• To start sampling

1. Start the sampling operation by performing one of the function key operations described below.
   - If the final Setup Wizard screen is on the display, press F1(YES).
   - If the Advanced Setup menu screen is on the display, press F1(START).
   - If the E-CON main menu screen is on the display, press F4(START).

   - This sets up the EA-100 using the setup data in the current setup memory area.



```
======== EA-100 ========
  Setting EA-100...

     Cancel:[AC]
```

   - To interrupt a setup while the above screen is on the display, press AC.

2. The sampling start dialog box appears after setup of the EA-100 is complete.
   - The content of the sampling start dialog box depends on the settings contained in the setup. See "Operations during a sampling operation" below for information about this dialog box and other display screens.

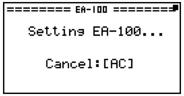
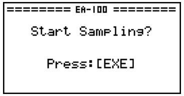
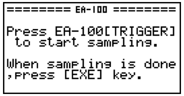
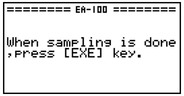
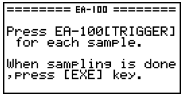
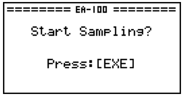
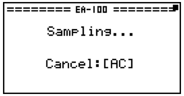
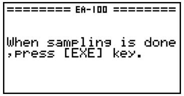
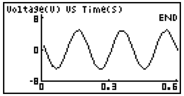
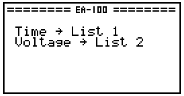
• Operations during a sampling operation

Sending a sample start command from the calculator to the EA-100 causes the following sequence to be performed.

Setup Data Transfer → Sampling Start → Sampling End →
Transfer of Sample Data from the EA-100 to the Calculator

The table on the next page shows how the trigger conditions and sensor type specified in the setup data affects the above sequence.

Starts Sampling

Sampling Type	**Real-Time Sampling**	**Normal Sampling** Press [EXE] to start.	**Normal Sampling** Press [TRIGGER] to start.	**Trigger Start Sampling**	**[TRIGGER] Key Sampling**	**Photogate measurement**
Real-Time	Yes	No				
Sampling Interval	Timer				[TRIGGER] key press	Gate Status
Start Trigger	[EXE] key		[TRIGGER]	Sampled Value		
1. EA-100 Setup	 ======== EA-100 ======== Setting EA-100... Cancel:[AC]					
2. Trigger Conditions	 ======== EA-100 ======== Start Sampling? Press:[EXE]		 ======== EA-100 ======== Press EA-100[TRIGGER] to start sampling. When sampling is done ,press [EXE] key.	 ======== EA-100 ======== When sampling is done ,press [EXE] key.	 ======== EA-100 ======== Press EA-100[TRIGGER] for each sample. When sampling is done ,press [EXE] key.	 ======== EA-100 ======== Start Sampling? Press:[EXE]
3. Sampling		 ======== EA-100 ======== Sampling... Cancel:[AC]				 ======== EA-100 ======== When sampling is done ,press [EXE] key.
4. Data Receive Trigger		Sampled values received automatically.				
5. Graph Drawing	 Voltage(V) VS Time(S)	Data is not graphed under the following conditions. 1. Interval: [TRIGGER] Rec Time: None 2. Motion Detector 0.02≦Sampling Interval (sec) <0.065 Rec Time: None 3. Only when Photogate sensor is used				
6. Data Store Lists	 ======== EA-100 ======== Time → List 1 Voltage → List 2					

Conductivity, heart rate, and pH sensors
Sample values produced by these types of sensors lose accuracy unless the sensors are allowed to warm up. Perform the following procedure to ensure better sampling accuracy.

Using a Heart Rate Sensor

1. Select [TRIGGER] as the Trigger Source item of Advanced Setup's Trigger parameter.
2. When the EA-100 is in the Ready state prior to sampling, hold down the EA-100's [TRIGGER] key for about 20 to 30 seconds, and then release it.
3. Press the EA-100's [TRIGGER] key when you want to start sampling.

Using a Conductivity or pH Sensor

1. Select [Yes] for the [Real-Time] setting on the Sample Setup screen of the Advanced Setup menu.

Initial samples using conductivity, heart rate, and pH sensors are always inaccurate when starting from Setup Wizard.

For detailed information about a sensor, see the documentation that comes with it.

Index (Additional Functions)

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maar inleveren als
KCA**

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London NW2 7JD, U.K.

Important!
Please keep your manual and all information handy for future reference.

CASIO®

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