CASIO

CASIO COMPUTER CO., LTD.
6-1, Nishi-Shinjuku 2-chome
Shinjuku-ku, Tokyo 163-02, Japan

SA1141C (英) Printed in China

fx-9700GH Owner's manual

CASIO

POWER GRAPHIC

fx-9700GH

Owner's manual

(英)

CASIO

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.

Caution: Changes or modification to the product not expressly approved by CASIO could void the user's authority to operate the product.

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-121 Ver 2.0	Power Graphic Unit to PC for IBM/Macintosh Machine

IBM is a registered trademark of International Business Machines Corporation.
Macintosh is a registered trademark of Apple Computer, Inc.

Quick-Start

Welcome to the world of Graphing Calculators and the CASIO fx-9700GH.

Quick-Start is not a complete tutorial, but it will take you through many of the most common functions, from turning the power on through graphing complex equations. When you're done, you'll have mastered the basic operation of the fx-9700GH and will be ready to proceed with the rest of this manual to learn the entire spectrum of functions the fx-9700GH can perform.

Each step of every example is shown graphically to help you follow along quickly and easily. For example, when you need to enter the number 57, 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, or in fact you need to start over for any reason, you can do so by pressing the "All Clear" button. [AC ON]

POWER ON/OFF

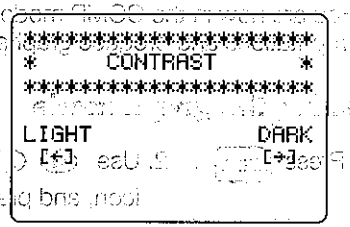
To turn your unit on, press [AC ON]

To turn your unit off, press [SHIFT] [AC OFF ON]

NOTE: *Your unit will automatically shut itself off after six minutes of inactivity.*

ADJUSTING THE CONTRAST

1. Press [MENU]
2. Use ◀ ▶ ▲ ▼ to select the CONT icon, and press [EXE]. The following screen will appear:



3. Press ◀ to lighten screen or ▶ to darken screen.
4. Press [MENU] to clear the screen.

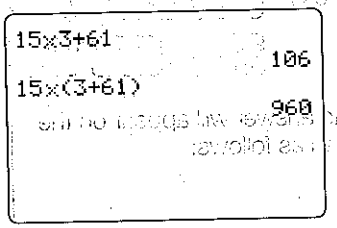
Grouping within an equation

You can also group certain operations within your equation using the parentheses keys. ( ) ( )

EXAMPLE: 15 x (3 + 61)

1. Press [1] [5] [×] [(] [3] [+] [6] [1] [)] [EXE]

The following screen will appear:



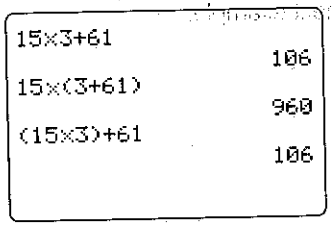
Note that your previous calculation remains on the screen. The new calculation is displayed beneath it for easy comparison.

Now let's try a variation on that problem by positioning the parentheses differently.

EXAMPLE: (15 x 3) + 61

1. Press [(] [1] [5] [×] [3] [)] [+] [6] [1] [EXE]

The following screen will appear:



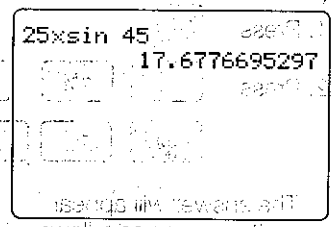
As you can see, the fx-9700GH displays all three problems simultaneously.

USING BUILT-IN VALUES

The fx-9700GH features several convenient built-in functions and values that you can enter into your equations quickly and easily.

EXAMPLE: 25 x sine of 45 (In Deg mode)

1. Press [AC/ON]
2. Press [2] [5] [×] [sin] [4] [5]

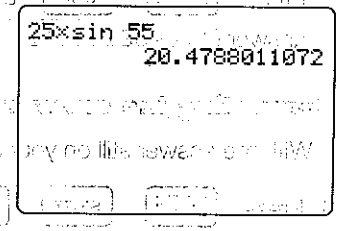


3. Press [EXE] and the answer will appear on the screen as follows:

Using the Replay feature

With the replay feature, you can go back in and change any part of your equation at any time, even after the fx-9700GH computes the answer, without having to rewrite the entire equation. We'll use the previous equation as an example. Let's say you need to change the sine of 45 to sine of 55, but everything else in the equation remains the same.

1. Press [◀] This will bring you back into the equation.
2. Press [◀] twice so the flashing cursor is on the 4.
3. Press [5] to overwrite a 5.
4. Press [EXE] and the fx-9700GE will quickly recompute the new solution:



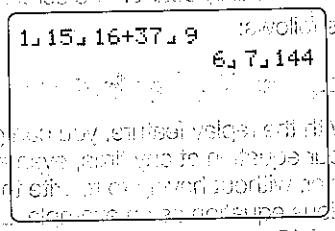
FRACTIONS

The fx-9700GH makes it easy to work with fractions with its fraction key. [a b/c] On screen, the ⌟ symbol is entered between each value of the fraction. For example, $1\frac{15}{16}$ would appear as 1⌟15⌟16

EXAMPLE: $1\frac{15}{16} + \frac{37}{9}$

1. Press [AC/ON]
2. Press [1] [a b/c] [1] [5] [a b/c] [1] [6]
   [+] [3] [7] [a b/c] [9] [EXE]

The answer will appear on the screen as follows:



Converting the answer to a decimal equivalent

With the answer still on your screen,

1. Press [EXE] [a b/c] and the decimal equivalent of your answer (6.04861111111) will appear on the screen.

Converting the answer to an improper fraction

With the answer still on your screen,

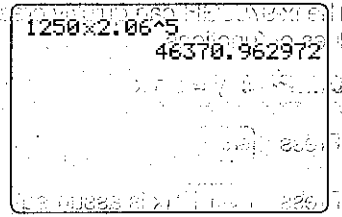
1. Press [EXE] [SHIFT] [a b/c] and your answer (871⌟144) will appear on the screen in the form of an improper fraction.

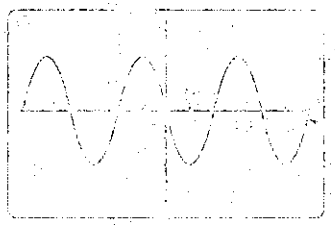
EXPONENTIALS

Exponentials are another function the fx-9700GH can perform quickly and easily.

EXAMPLE: 1250×2.06^5

1. Press [AC/ON]
2. Press [1] [2] [5] [0]
   [×] [2] [.] [0] [6]
3. Now you are ready to enter the exponent value. Press the exponent key [^] and ^ will appear on the screen. The number directly preceding the ^, in this case 2.06, is the base number.
4. Press [5] The number 5 now appears after the ^ symbol, and represents the exponential value.
5. Press [EXE] and the answer will appear on the screen as follows:





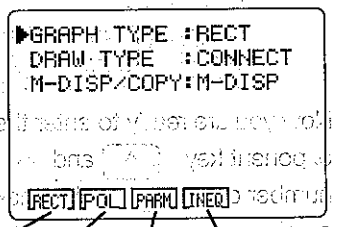
GRAPHING

The fx-9700GH has the ability to present graphic solutions to a variety of complex equations. Before drawing a graph, be sure to first specify the graph type.

Specifying the graph type

1. Select the COMP (computation) mode.
2. Press [SHIFT] [MENU] (SET UP)

   The following screen will appear:



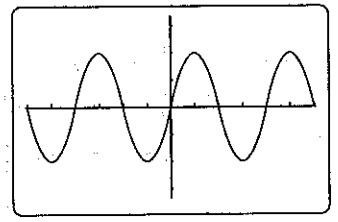
3. Press [F1] to specify the RECT mode for drawing of a rectangular coordinate graph.
4. Press [EXIT] to return to the previous screen.

Graphing a built-in function

The fx-9700GH can quickly create a graph of one of its built-in values or functions.

EXAMPLE: y = sin x

5. Press [Graph]
6. Press [sin] (x is assumed)
7. Press [EXE] and the following graph will appear:



Returning to the equation

If you find that you need to return to your equation to change or replace certain values, you can do so simply by pressing the Graph-Text toggle key. [G↔T]

The fx-9700GH has two separate areas of its memory: one for your formula, the other for graphs.

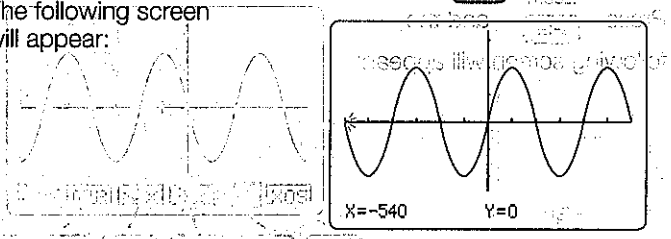
1. Press [G↔T] once to see the equation, then again to see the graph.

Trace function

The trace function lets you select an exact point on the graph and display the coordinates of that point.

1. With the graph still on your screen, press [Trace] [F1]

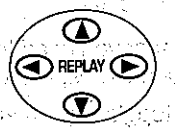
   The following screen will appear:



Notice that a cursor has appeared at the left-most point on the X axis and its coordinates have appeared at the bottom of the screen. Move the cursor to the right by pressing the ▶ key, then back to the left using the ◀ key. Pressing the button once will move the cursor one point, while holding it down will cause continuous movement. (The values may be approximated due to the space limitations of the screen.)

2. Press [Coord] [F6] to view the full value of the X coordinate in unabbreviated form.
3. Press [Coord] [F6] to view the full value of the Y coordinate in unabbreviated form.
4. Press [Coord] [F6] a third time to see both coordinates simultaneously.
5. Press [Trace] [F1] to exit the trace function.

Scrolling in four directions



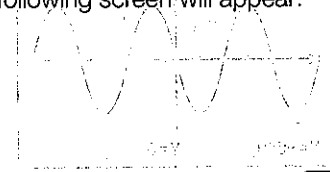
1. Pressing any arrow key lets you scroll to see different sections of your graph.

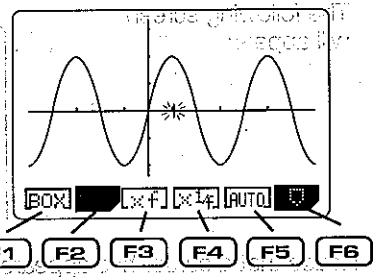
Returning to your original graph

After scrolling, you needn't retrace your steps to get back to your original graph. You can do it quickly and easily using the function keys (F keys) to enter a selection from one of the many FUNCTION MENUS the fx-9700GH employs. A function menu is a group of up to 6 functions that are displayed across the bottom of the screen. To select one of the choices, press the corresponding F key.

2. Using the ▶ key, scroll so the Y axis is at the left of the screen.

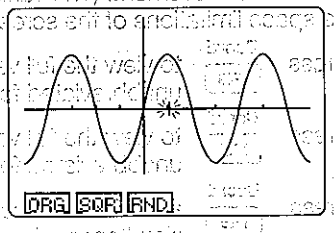
3. Press Zoom [F2] and the following screen will appear:





The first five function key menu items at the bottom of the screen perform functions. The sixth one (on the far right) displays the next function menu.

4. Press [F6] and the following screen will appear:



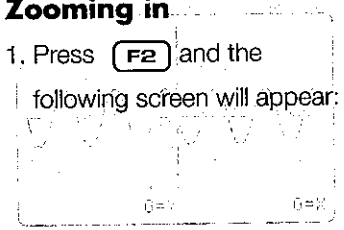
5. To return the display to its original size, press [F1]

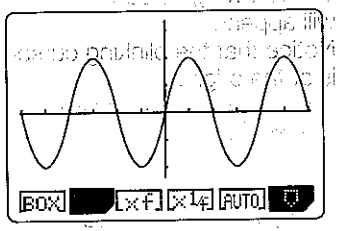
Zoom function

Another of the powerful graphing features of the fx-9700GH is zooming. This allows you to enlarge a portion of your graph for detailed analysis, or zoom out for a broader view.

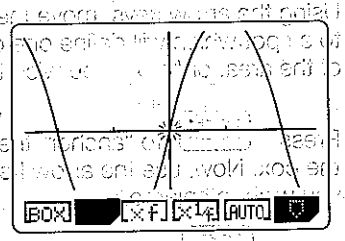
Zooming in

1. Press [F2] and the following screen will appear:





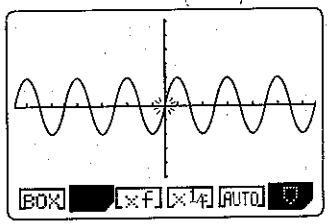
2. Press [F3] which corresponds to the ×f box on the screen, to zoom in on your graph. The screen will now show a view that is enlarged by a predetermined factor. (Later in the manual, you'll learn how to set your own factor of enlargement or reduction.)



3. Press [F6] [F1] to return the graph to its original size.

Zooming out

4. Press [F2] [F4] which corresponds to ×1/f on the screen, to zoom away from the graph. The screen should now look like this:



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 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.
- Avoid using volatile liquids such as thinner or benzine to clean the unit. Wipe it with a soft, dry cloth, or with a cloth that has been dipped in a solution of water and a neutral detergent and wrung out.
- In no event will the manufacturer and its suppliers be liable to you or any other person for any damages, expenses, lost profits, lost savings or any other damages arising out of loss of data and/or formulas arising out of malfunction, repairs, or battery replacement. The user should prepare physical records of data to protect against such data loss.
- Never dispose of batteries, the liquid crystal panel, or other components by burning them.
- When the "Low battery" message appears on the display, replace the main power supply batteries as soon as possible.
- Be sure that the power switch is set to OFF when replacing batteries.
- If the calculator is exposed to a strong electrostatic charge, its memory contents may be damaged or the keys may stop working. In such a case, perform the All Reset operation to clear the memory and restore normal key operation.
- Note that strong vibration or impact during program execution can cause execution to stop or can damage the calculator's memory contents.
- Using the calculator near a television or radio can cause interference with TV or radio reception.
- Before assuming malfunction of the unit, be sure to carefully reread this manual and ensure that the problem is not due to insufficient battery power, programming or operational errors.

Important

In no event shall CASIO Computer Co., Ltd. be liable to anyone for special, collateral, incidental, or consequential damages in connection with or arising out of the purchase or use of these materials. Moreover, CASIO Computer Co., Ltd. shall not be liable for any claim of any kind whatsoever against the use of these materials by any other party.

- The contents of this manual are subject to change without notice.
- No part of this manual may be reproduced in any form without the express written consent of the manufacturer.
- The options described in Chapter 13 of this manual may not be available in certain geographic areas. For full details on availability in your area, contact your nearest CASIO dealer or distributor.

Creating the graph

An integration graph is just one of many types of graphs the fx-9700GH can generate in just a few keystrokes.

EXAMPLE: $\int_1^5 (x-1)(x-5)\,dx$

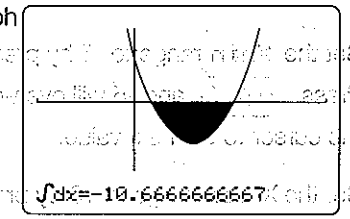
10. Press SHIFT G↔T (G-∫dx)

11. Press (X,θ,T — 1)

(X,θ,T — 5)

SHIFT → 1 SHIFT → 5

12. Press EXE and your graph will appear on screen as follows:
(Shading is automatic)



POLAR GRAPH

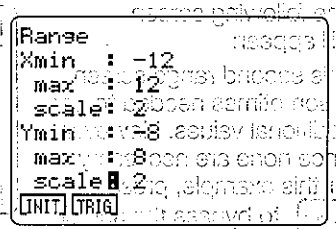
Setting the mode (In Rad mode)

1. Press SHIFT 1 F2 EXE SHIFT SET UP MENU F2
to specify the POL mode for drawing of a polar coordinate graph, and then press EXIT EXIT .

Setting the range

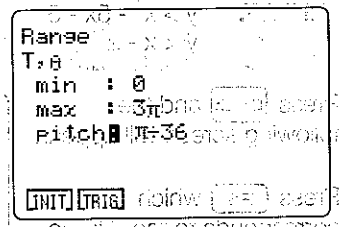
2. Press AC ON

3. Set the range parameters to match the following screen.
Remember to press EXE after each value to move the cursor to the next field.
If you have trouble, refer back to page XIII.



Polar graph cont'd

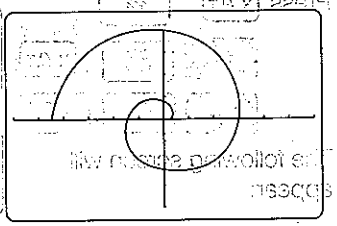
3. This time, we will also need to enter values in the second range screen. Set those to match the screen to the right.
Remember to press EXE after each value is entered.



Creating the graph

EXAMPLE: $r = \theta$

4. Press Graph X,θ,T EXE and the graph will appear on the screen as follows:



INEQUALITY GRAPH

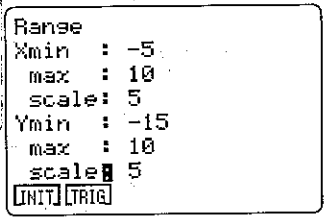
Setting the mode

1. Press SHIFT SET UP MENU F4 to specify the INEQ mode for drawing of an inequality graph, and then press EXIT .

Setting the range

2. Press AC ON

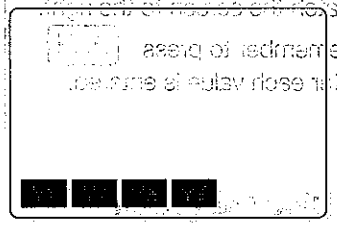
3. Set the range parameters to match the following screen.
Remember to press EXE after each value to move the cursor to the next field.
When the second range screen appears, press Range to bypass it, as again it is unnecessary for this example.



Creating the graph

EXAMPLE: $y > x^2 - 5x - 5$
$y < x - 2$

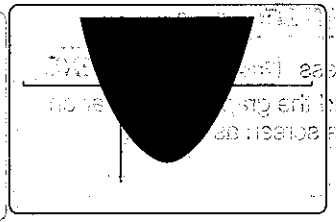
4. Press [Graph] and the following screen will appear:



5. Press [F1] which corresponds to the 'Y>' box on the screen.

6. Press [X,θ,T] [x^2]
[−] [5] [X,θ,T]
[−] [5] [EXE]

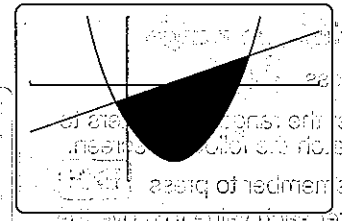
The following screen will appear:



7. Press [Graph] to enter the next inequality.

8. Press [F2] which corresponds to the 'Y<' box on the screen.

9. Press [X,θ,T] [−] [2] [EXE]. The following screen will appear:



INPUTTING FUNCTIONS AND DRAWING GRAPHS

With the fx-9700GH, you first input the function of the graph, and then draw the graph using the function. Be sure to always specify the graph type before inputting the function.

EXAMPLE: $y = 2x^2 - 3$

Inputting the function

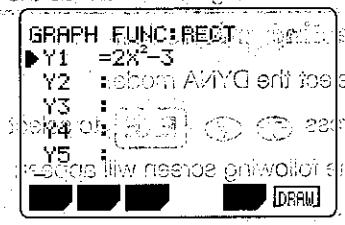
1. Select the GRAPH mode.

2. Press [F3] [F1] to specify the RECT mode for drawing of a rectangular coordinate graph.

3. Press [2] [X,θ,T] [x^2] [−] [3]

4. Press [F1] [F6].

The following screen will appear:

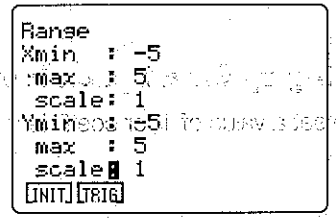


Setting the range

5. Press [AC ON]

6. Set the range parameters to match the following screen.

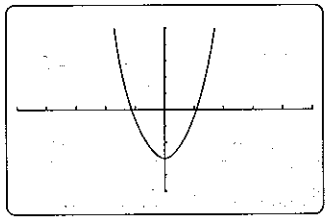
Remember to press [EXE] after each value to move the cursor to the next field. When the second range screen appears, press [Range] to bypass it, as again it is unnecessary for this example.



Drawing the graph of the function

7. Press [F6]

The graph will appear on the screen as follows:



DYNAMIC GRAPH

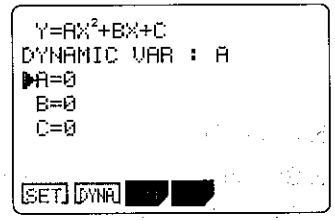
The Dynamic Graph capabilities of the fx-9700GH lets you see how a graph is affected by changes in the coefficients of its function.

EXAMPLE: To graph $Y = ax^2$ as the value of a changes from 1 to 3.

Selecting a function

1. Select the DYNA mode.
2. Press [▼] [▼] [EXE] to select the function you want.

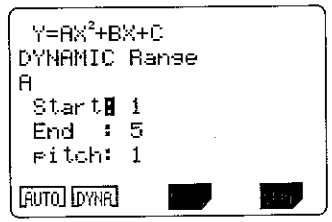
The following screen will appear:



Setting up for a Dynamic Graph

3. To set a value of 1 for coefficient A, press [1] [EXE].

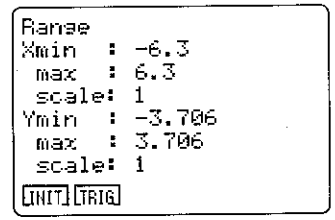
4. Press [F3] and the following screen will appear:



5. Press [EXE] [3] [EXE].

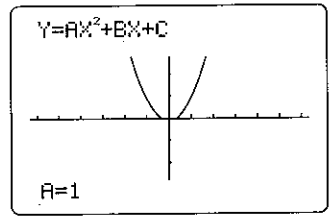
Setting the graph's range parameters

6. Press [F6]
7. Press [Range] [F1] and the following screen will appear:

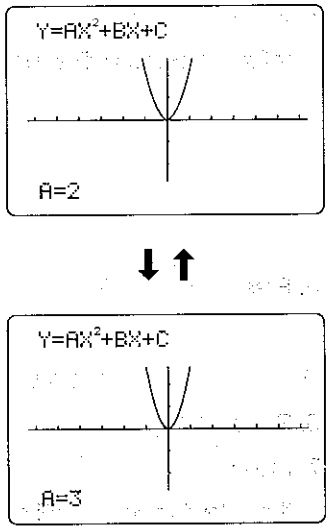


Drawing a Dynamic Graph

8. Press [EXIT] [F2], and the graph will change as shown here.



↓↑



POWER GRAPHIC
fx-9700GH

If you've completed this Quick-Start section, you are well on your way to becoming an expert user of the CASIO fx-9700GH PowerGraphic Calculator.

To learn all about the many powerful features of the fx-9700GH, read on and explore!

Contents

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 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.
- Avoid using volatile liquids such as thinner or benzine to clean the unit. Wipe it with a soft, dry cloth, or with a cloth that has been dipped in a solution of water and a neutral detergent and wrung out.
- In no event will the manufacturer and its suppliers be liable to you or any other person for any damages, expenses, lost profits, lost savings or any other damages arising out of loss of data and/or formulas arising out of malfunction, repairs, or battery replacement. The user should prepare physical records of data to protect against such data loss.
- Never dispose of batteries, the liquid crystal panel, or other components by burning them.
- When the "Low battery" message appears on the display, replace the main power supply batteries as soon as possible.
- Be sure that the power switch is set to OFF when replacing batteries.
- If the calculator is exposed to a strong electrostatic charge, its memory contents may be damaged or the keys may stop working. In such a case, perform the All Reset operation to clear the memory and restore normal key operation.
- Note that strong vibration or impact during program execution can cause execution to stop or can damage the calculator's memory contents.
- Using the calculator near a television or radio can cause interference with TV or radio reception.
- Before assuming malfunction of the unit, be sure to carefully reread this manual and ensure that the problem is not due to insufficient battery power, programming or operational errors.

Important

In no event shall CASIO Computer Co., Ltd. be liable to anyone for special, collateral, incidental, or consequential damages in connection with or arising out of the purchase or use of these materials. Moreover, CASIO Computer Co., Ltd. shall not be liable for any claim of any kind whatsoever against the use of these materials by any other party.

About This Manual.....

This manual is divided into chapters to help you find the operation you want quickly and easily.

Chapter 1 Getting Acquainted
This chapter gives you a general introduction to the various capabilities of the unit. It contains important information about the unit, so you should be sure to read it before starting operation.

Chapter 2 Manual Calculations
Manual calculations are those that you input manually, as on the simplest of calculators. This chapter provides various examples to help you become familiar with manual calculations.

Chapter 3 Differential, Integration, and Σ Calculations
This chapter tells you how to perform differential, integration, and Σ calculations on this unit.

Chapter 4 Complex Numbers
This chapter describes how to perform calculations involving complex numbers.

Chapter 5 Statistical Calculations
This chapter tells you how to perform single-variable statistical calculations using standard deviation, and paired-variable statistical calculations using regression. No matter what type of statistical calculations you decide to perform, you can tell the unit to either store the statistical data or not to store the data.

Chapter 6 Using the Matrix Mode
This chapter tells you how to perform calculations using matrices, which a maximum size of 255 rows × 255 columns.

Chapter 7 Equation Calculations
This chapter details procedures for solving linear equations with two to six unknowns, quadratic equations, and cubic equations.

Chapter 8 Graphing
This chapter explains everything you need to know to fully use the versatile graphing capabilities of the unit.

Chapter 9 Dual Graph
This chapter explains how to use the Dual Graph, which lets you display two graphs at the same time.

Chapter 10 Dynamic Graphing
This chapter tells you how to use the Dynamic Graph Mode, which makes it possible to sequentially change the values of function coefficients within a specific range, and draw the resulting graphs.

Chapter 11 Table & Graph Mode
This chapter details operations in the Table & Graph Mode, which lets you generate a numeric table for a function or recursion formula, and then draw the resulting graph.

Chapter 12 Program/File Editor Mode
This chapter tells you how to input a program and store it in the memory's program area. It also describes how to use the File Editor to store program as file data and then recall it for execution.

Chapter 13 Data Communications
This chapter explains how to exchange data between two Power Graphic units or between your Power Graphic unit and a personal computer.
This chapter also contains information on how to connect to a Label Printer to transfer screen data for printing.

Appendix
The appendix contains information on battery replacement, error messages, specifications, and other technical details.

Important

Reset your calculator before using it for the first time!
See page 323 for details on the reset procedure.

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

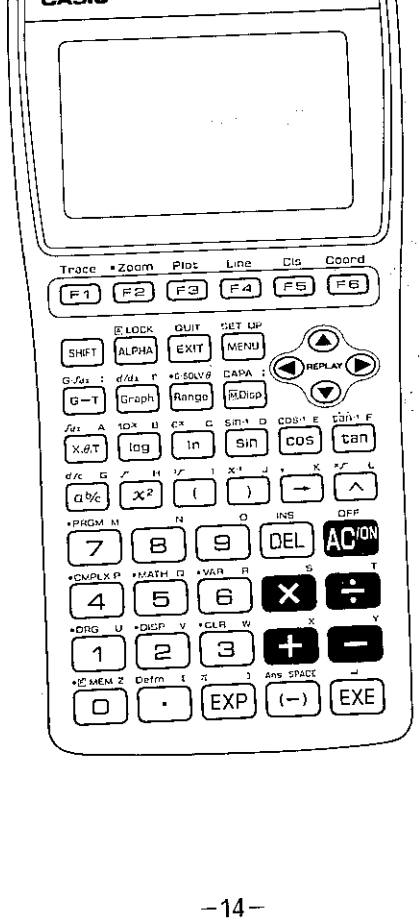
Chapter 1

Getting Acquainted

Chapter 1 Getting Acquainted

This chapter gives you a general introduction to the various capabilities of the unit. It contains important information about the unit, so you should be sure to read it before starting operation.

1-1 Keys and Their Functions



■The Keyboard

Many of the unit'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.

Shifted function (orange)——10^x B——Alpha function (red)
Primary function——log

Also note that green markings show the names of menus that appear when the SHIFT is pressed.

• Primary Functions

These are the functions that are normally executed when you press the key.

• Shifted Functions

You can execute these functions by first pressing the SHIFT key, followed by the key that is assigned the shifted function you want to execute.

• Alpha Functions

An alpha function is actually the simple input of an alphabetic letter. Press the ALPHA key, followed by the key that is assigned the letter you want to input.

Alpha Lock

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

■Key Operations

Trace Coord
F1 ~ F6 Function/Graph Function Keys

- Use these keys to select one of the functions that appear along the bottom of the display.
- After drawing a graph, use these keys to access the built in graphic functions marked above them on the panel.

SHIFT Shift Key

- Press this key to shift the keyboard and access the functions marked in orange (or green). The S indicator on the display indicates that the keyboard is shifted. Pressing SHIFT again unshifts the keyboard and clears the S indicator from the display.
- This key is also used during display of a Mode Menu to advance to the next Mode Menu screen.

LOCK
ALPHA Alpha Key

- Press this key to input a letter marked in red on the keyboard.
- Press this key following SHIFT to lock the keyboard into alphabetic character input. To return to normal input, press ALPHA again.

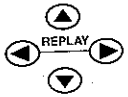
A313043-2

QUIT
[EXIT] **Exit/Quit Key**

- Press this key to back step through displays, from a display reached by pressing function keys.
- Pressing this key while a calculation result is displayed switches to the display from which the function was selected to perform the calculation.
- Press this key following [SHIFT] to quit an operation and return to the initial display of the current mode.

SET UP
[MENU] **Menu/Set Up Key**

- Press this key to display the Main Menu.
- Press this key following [SHIFT] while a set up display is shown to change to the set up edit display.



Cursor/Replay Keys

- Use these keys to move the cursor on the display.
- After you press the [EXE] key following input of a calculation or value, press ◀ to display the calculation from the end, or ▶ to display it from the beginning. You can then execute the calculation again, or edit the calculation and then execute it. See page 33 for details on the Replay Function.

∫dx :
[G↔T] **Graphic ↔ Text/Integration Graph Key**

- Press this key to switch between the graphic display and text display.
- Press this key following [SHIFT] when you want to draw an integration graph.

d/dx r
[Graph] **Graph/Differential Key**

- Press this key before entering a calculation formula for graphing.
- Press this key following [SHIFT] when you want to perform differential calculations (page 74).
- Press this key following [ALPHA] to enter the letter *r*.

G-SOLV θ
[Range] **Range/Gaph Solve Menu Key**

- Use this key to set or check the range of a graph.
- Press this key following [SHIFT] to display a graph solve menu of functions that let you calculate root and maximum/minimum values, etc. from a graph.
- Press this key following [ALPHA] to enter the letter θ.

CAPA :
[M-Disp] **Mode Display/Screen Copy/Capacity Key**

- When this key is set to function as a Mode Display Key (page 39), it can be used to check the current set up display settings. The settings remain displayed while this key is depressed.
- When this key is set to function as a Screen Copy Key, pressing it sends a bit pattern of the current display image to a connected personal computer (page 318).
- When this key is set to function as a Mode Display Key, press this key following [Shift] to check the current status of the unit's memory capacity. The capacity remains displayed while this key is depressed.

∫dx A
[X,θ,T] **Variable/Integration Key**

- Use this key to input variables X, θ, or T when performing differentials, integrations, or graphic functions.
- Press this key following [SHIFT] to input variables for integration calculations.
- Press this key following [ALPHA] to enter the letter A.

10^x B
[log] **Common Logarithm/Antilogarithm Key**

- Press this key and then enter a value to calculate the common logarithm of the value.
- Press [SHIFT][10^x] and then enter a value to make the value an exponent of 10.
- Press this key following [ALPHA] to enter the letter B.

e^x C
[ln] **Natural Logarithm/Exponential Key**

- Press this key and then enter a value to calculate the natural logarithm of the value.
- Press [SHIFT][e^x] and then enter a value to make the value an exponent of *e*.
- Press this key following [ALPHA] to enter the letter C.

sin⁻¹ D cos⁻¹ E tan⁻¹ F
[sin] [cos] [tan] **Trigonometric Function Keys**

[sin]
- Press this key and then enter a value to calculate the sine of the value.
- Press this key following [ALPHA] to enter the letter D.

[cos]
- Press this key and then enter a value to calculate the cosine of the value.
- Press this key following [ALPHA] to enter the letter E.

[tan]
- Press this key and then enter a value to calculate the tangent of the value.
- Press this key following [ALPHA] to enter the letter F.

[SHIFT][sin]
- Perform this operation and then enter a value to calculate the inverse sine of the value.

[SHIFT][cos]
- Perform this operation and then enter a value to calculate the inverse cosine of the value.

[SHIFT][tan]
- Perform this operation and then enter a value to calculate the inverse tangent of the value.

d/c G
[a b/c] **Fraction Key**

- Use this key when entering fractions and mixed fractions. To enter the fraction 23/45, for example, press 23[a b/c]45. To enter 2-3/4, press 2[a b/c]3[a b/c]4.
- Press [SHIFT][d/c] to display an improper fraction.
- Press this key following [ALPHA] to enter the letter G.

√ H
[x²] **Square/Square Root Key**

- Enter a value and press this key to square the entered value.
- Press [SHIFT][√] and then enter a value to calculate the square root of the value.
- Press this key following [ALPHA] to enter the letter H.

Shift I
[(] **Open Parenthesis/Cube Root Key**

- Press this key to enter an open parenthesis in a formula.
- Press [SHIFT][∛] and then enter a value to calculate the cube root of the value.
- Press this key following [ALPHA] to enter the letter I.

Close Parenthesis/Reciprocal Key

- Press this key to enter a close parenthesis in a formula.
- Enter a value and then press SHIFT x⁻¹ to calculate the reciprocal of the value.
- Press this key following ALPHA to enter the letter J.

Assignment/Comma Key

- Press this key before entering a value memory name to assign the result of a calculation to the value memory.
- Press this key following SHIFT to input a comma.
- Press this key following ALPHA to enter the letter K.

Power/Root Key

- Enter a value for x, press this key, and then enter a value for y to calculate x to the power of y.
- Enter a value for x, press SHIFT √, and then enter a value for y to calculate the xth root of y.
- Press this key following ALPHA to enter the letter L.

0 ~ 9, . Numeric Keys and Decimal Key

- Use the numeric keys to enter a value. Enter decimals using the decimal key.
- Following operation of the ALPHA key, each of the numeric keys enters the following letters.
  - ALPHA 7 enters M.
  - ALPHA 8 enters N.
  - ALPHA 9 enters O.
  - ALPHA 4 enters P.
  - ALPHA 5 enters Q.
  - ALPHA 6 enters R.
  - ALPHA 1 enters U.
  - ALPHA 2 enters V.
  - ALPHA 3 enters W.
  - ALPHA 0 enters Z.
  - ALPHA . enters the open bracket [.
- Following operation of the SHIFT key, the menus marked in green (or orange) above these keys are accessed.

SHIFT MEM — **Function Memory Menu**
This key operation displays the menu used for function memory calculations (see page 40).

SHIFT DRG — **Unit of Angular Measurement Menu**
This key operation displays the menu used for specification of the unit of angular measurement.

SHIFT DISP — **Display Format Menu**
This key operation displays the menu used for specification of the display format for calculation results.

SHIFT CLR — **Clear Menu**
This key operation displays the menu used for clearing memory contents.

SHIFT CMPLX — **Complex Number Calculation Menu**
This key operation displays the menu used for complex number calculation.

SHIFT MATH — **Built-in Function Menu**
This key operation displays the menu used for specification of built-in functions and engineering symbols (k, μ, etc.)

SHIFT VAR — **Variable Data Menu**
This key operation displays the menu used for a graph range, zoom factors, graph functions, statistical data, equation solutions and coefficients, and the Table & Graph functio

SHIFT PRGM — **Program Command Menu**
This key operation displays the menu used for specification of special built-in program functions.

SHIFT Defm EXE
This key sequence displays the status of the program, function, variable, statistic (SD and LR), and matrix memories, along with the remaining number of bytes.

For full details on each menu, see the section titled "Basic Set Up", "Basic Operation" starting from page 25.

AC/ON All Clear/ON/OFF Key

- Press this key to switch power on.
- Press this key while power is on to clear the display.
- Press this key following SHIFT to switch power off.

DEL Delete/Insert Key

- Press this key to delete the character at the current cursor location.
- Press SHIFT INS to display the insert cursor ( ]). You can insert characters while the insert cursor is displayed.

+ − × ÷ Arithmetic Operation Keys

- Input addition, subtraction, multiplication, and division calculations as they are written, from left to right. Press the applicable key to specify an arithmetic operation.
- You can also use the + and − keys to specify positive and negative values.
- Following operation of the ALPHA key, each of these keys enters the following letters.
  - ALPHA × enters S.
  - ALPHA ÷ enters T.
  - ALPHA + enters X.
  - ALPHA − enters Y.

EXP Exponent/Pi Key

- Use this key when entering a mantissa and exponent. To input 2.56×10^{34}, for example, enter 2.56 EXP 34.
- Press SHIFT π to input the value of π.
- Press this key following ALPHA to enter the closed bracket].

(−)/Answer/SPACE Key

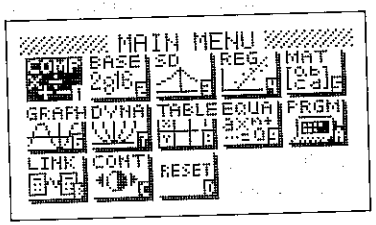
- Press this key when entering a negative value.
- Press SHIFT and then this key to recall the most recent calculation result obtained using the EXE key.
- Press ALPHA and then this key to enter a space.

EXE Execute/Newline Key

- Press this key to obtain the result of a calculation. You can press this key following data input, or after a result is obtained to execute the calculation again using the previous result.
- Press SHIFT ↵ to perform a newline operation.

1-2 Modes

You can control the operations of the unit by entering the correct *mode*. To select the mode you need, select the appropriate icon from the *Main Menu*. The Main Menu appears whenever you press the [MENU] key.



The icon that is highlighted is the one that is currently *selected*. Use the cursor keys to move the highlighting around the display to select the mode that you want. To enter the highlighted mode, press the [EXE] key.

- In addition to using the cursor keys to select a mode's icon, you can also select a mode by inputting a number or letter. Input the number or letter in the lower right corner of the icon to select the mode you want.
- Use only the procedures described above to enter a mode. If you use any other procedure, you may end up in a mode that is different than the one you thought you selected.

The following explains the meaning of each icon in the Main Menu.

COMP Mode
Use this mode for arithmetic calculations and function calculations, for drawing graphs and for executing programs.

BASE Mode
Use this mode for binary, octal, decimal, and hexadecimal calculations and conversions. This mode is also used for logical operations.

SD Mode
Use this mode for single-variable statistical calculations (standard deviation).

REG Mode
Use this mode for paired-variable statistical calculations (regression).

MAT Mode
Use this mode for matrix calculations.

GRAPH Mode
Use this mode to input functions and draw their graphs.

DYNA Mode
Use this mode to store graph functions and to draw graphs by changing the values for variables in the functions.

TABLE Mode
Use this mode to store a function or recursion formula, to generate a numeric table by changing values for variables in the function/formula, and to draw graphs.

EQUA Mode
Use this mode to solve linear equations with two through six unknowns, quadratic equations, and cubic equations.

PRGM Mode
Use this mode to store programs in the program area, to execute programs, and to store and execute programs as file data.

LINK Mode
Use this mode to transfer program, function, matrix, and other memory data to another unit.

CONT Mode
Use this mode to adjust the display contrast.

RESET Mode
Use this mode to reset the calculator to its initial parameters.

■Set Up Displays

Except for the LINK, CONT, and RESET modes, entering a mode causes a *set up display* to appear first. The set up displays show the current status of other modes that are related to the mode you entered. How a mode is set up affects the calculation results produced in the mode.

The status shown in each set up display shows initial settings that are in effect whenever the RESET operation (page 323) is performed.

• To change a set up

Select an icon and press [EXE] to display the set up display. Here we will enter the COMP Mode.

```
  RUN   /COMP
G-type  :RECT  /CONNECT
angle   :Deg
display :Norml
M-D/Cpy :M-Disp
```

Press [SHIFT][SETUP] to switch to the set up edit display.

```
▶GRAPH TYPE  :RECT
 DRAW TYPE   :CONNECT
 M-DISP/COPY :M-DISP

[RECT][POL][PARM][INEQ]
```

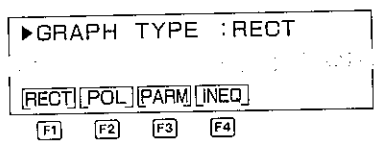
[F1] [F2] [F3] [F4]

Use the ▲ and ▼ cursor keys to move the pointer to the line whose set up you want to change.
Press the function key that corresponds to the setting that you want to make.
Press [EXIT] to return to the set up display.

Set Up Display Function Key Menus

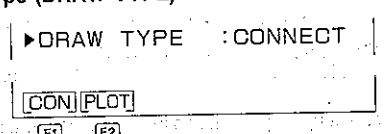
This section details the settings that you can make using the function keys in the set up edit display.

•Graph Type (GRAPH TYPE)



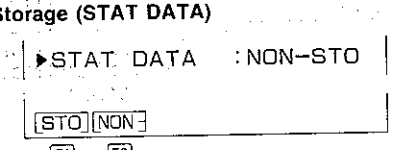
[F1](RECT) ..... Rectangular coordinate graph
[F2](POL) ..... Polar coordinate graph
[F3](PARM) ..... Parametric graph
[F4](INEQ) ..... Inequality graph

•Graph Drawing Type (DRAW TYPE)



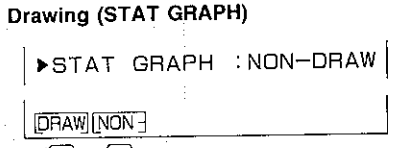
[F1](CON) ..... Connection of plotted points
[F2](PLOT) ..... No connection of plotted points

•Statistical Data Storage (STAT DATA)



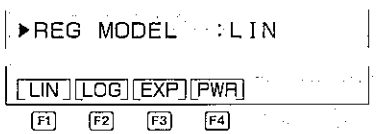
[F1](STO) ..... Storage of input statistical data into statistical data memory
[F2](NON-) ..... No storage of input statistical data into statistical data memory

•Statistical Graph Drawing (STAT GRAPH)



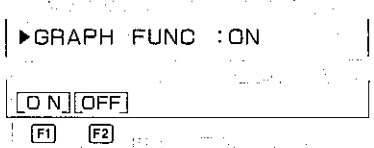
[F1](DRAW) .....: Drawing of graph using single-variable or paired-variable calculation results
[F2](NON-) ..... No drawing of graph using single-variable or paired-variable calculation results

•Paired-Variable Statistic Calculation (REG MODEL)



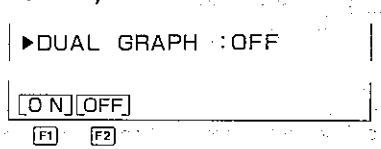
[F1](LIN) ..... Linear regression
[F2](LOG) ..... Logarithmic regression
[F3](EXP) ..... Exponential regression
[F4](PWR) ..... Power regression

•Graphic Function Display Settings (GRAPH FUNC)



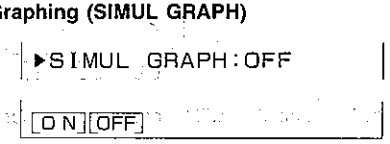
[F1](ON) ..... Switches on display of the function when drawing a graph or using Trace in the GRAPH Mode.
[F2](OFF) ..... Switches display of the function off.

•Dual Graph (DUAL GRAPH)



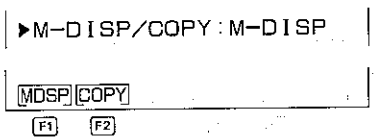
[F1](ON) ..... Switches on Dual Graph in the GRAPH Mode.
[F2](OFF) ..... Switches off Dual Graph.

•Simultaneous Graphing (SIMUL GRAPH)



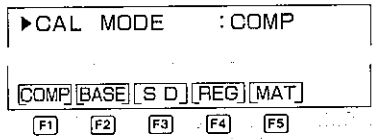
[F1](ON) ..... Simultaneous drawing of graphs for functions stored in graph function memory
[F2](OFF) ..... One-by-one drawing of graphs for functions stored in graph function memory

• [M·Disp] **Key Setting (M-DISP/COPY)**



[F1](MDSP) ..... Holding down [M·Disp] shows the set up display for the current mode.
[F2](COPY) ..... Pressing [M·Disp] enters a mode that makes it possible to transfer a bit pattern of the current display contents to a personal computer.

•After you select the PRGM Mode, you can use the set up display to specify the calculation mode (CAL MODE) for program execution. Whenever you change the calculation mode, the contents of the set up display change accordingly.



[F1](COMP) ..... Computation Mode
[F2](BASE) ..... Base-*n* Mode
[F3](SD) ..... Standard Deviation Mode
[F4](REG) ..... Regression Mode
[F5](MAT) ..... Matrix Mode

■About Function Key Icons

There are three types of function key icons that appear at the bottom of the display.

Example **MATRIX Mode**

[F1](Mat)
⋮
[F3](Trn)

This type of icon indicates that a function will be accessed (but not executed) when you press the function key.

[F4](LIST)

This type of icon indicates that another menu will appear when you press the function key.

[F5](SEE)

This type of icon indicates that a function will be executed as soon as you press the function key.

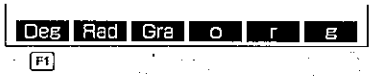
•In some cases, certain function keys may not be assigned functions, as is the case for [F6] in the above example. In such cases, no text appears above the function key.

1-3 Basic Set Up

■To Specify the Unit of Angular Measurement

Example **To set the unit of angular measurement as degrees**

[SHIFT][DRG]



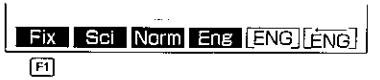
[F1](Deg)[EXE]

The relationship of the angular measurement units are:
360° = 2π radians = 400 grads
90° = π/2 radians = 100 grads

■To Specify the Number of Decimal Places

Example **To set the number of decimal places to 2**

[SHIFT][DISP]



[F1](Fix)[2][EXE]

Now all displayed values will be rounded off to the nearest integer at the second decimal place.

Important

- The above specification is applied to the displayed value only. The calculator still stores the entire 15-digit mantissa and 2-digit exponent of the result in memory. If you change the number of decimal places specification while a calculation result is displayed, the display changes to show the value using your new specification.
- No matter what settings are currently being applied for the number of decimal places, pressing [SHIFT][DISP][F3](Norm)[EXE] returns to the Norm mode (1 or 2).

■To Specify the Number of Significant Digits

Example **To set the number of significant digits to 3**

[SHIFT][DISP]

Fix Sci Norm Eng ENG ENG
[F2]

[F2](Sci)[3][EXE]

Sci 3
0.00E+00

Now all displayed values will be shown with 3 significant digits.

Important

- Pressing [F2](Sci)[0][EXE] causes all displayed values to be shown with 10 significant digits.
- The above specification is applied to the displayed value only. The calculator still stores the entire 15-digit mantissa and 2-digit exponent of the result in memory. If you change the number of significant digits specification while a calculation result is displayed, the display changes to show the value using your new specification.
- No matter what settings are currently being applied for the number of significant digits, pressing [SHIFT][DISP][F3](Norm)[EXE] returns to the Norm mode (1 or 2).

■To Specify the Display Format

[SHIFT][DISP]

Fix Sci Norm Eng ENG ENG
[F3]

[F3](Norm)[EXE]

Norm
0

Each time you press [SHIFT][DISP][F3](Norm)[EXE], the display format changes between Norm 1 and Norm 2. See page 55 for full details on Norm 1 and Norm 2.

Important

The above specification is applied to the displayed value only. The calculator still stores the entire 15-digit mantissa and 2-digit exponent of the result in memory. If you change the display format specification while a calculation result is displayed, the display changes to show the value using your new specification.

■To Specify the Engineering Mode

[SHIFT][DISP]

Fix Sci Norm Eng ENG ENG
[F4]

[F4](Eng)[EXE]

Eng
0

Each time you press [SHIFT][DISP][F4](Eng)[EXE], the unit enters or exits the Engineering Mode.

Important

The above specification is applied to the displayed value only. The calculator still stores the entire 15-digit mantissa and 2-digit exponent of the result in memory. If you change the engineering mode specification while a calculation result is displayed, the display changes to show the value using your new specification.

■To Adjust the Contrast of the Display

Highlight the **CONT** icon on the Main Menu.

[MENU]

[▼][◀][▶]

[EXE]

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

LIGHT              DARK
 [←]               [→]
```

[◀] make the screen lighter
[▶] to make the screen darker
[MENU] to return to the Main Menu

Important

If the display remains dim even when you adjust the contrast, you should replace batteries as soon as possible.

1-4 Basic Operation

The operations described here are fundamental calculations that you need to get started with the unit. Graphing, programming, and statistical calculations are covered in their own separate sections.

■Using the Clear Menu

The Clear Menu lets you clear either the entire memory of the unit or specific parts of the memory.

Important

- The procedures described below cannot be undone. Make sure that you do not need data any more before you delete it.
- You can call up the Clear Menu while the unit is in any mode.

• To clear the entire memory

[SHIFT][CLR]

Mcl Scl

[F1]

[F1](Mcl)[EXE]

Mcl

0

This operation clears all of the value memories, as well as any values assigned to r, θ, and variables.

• To clear statistical memories only

[SHIFT][CLR]

Mcl Scl

[F2]

[F2](Scl)[EXE]

Scl

0

- This operation clears any values assigned to Σx^2, Σx, n, Σy^2, Σy, and Σxy.
- In the case of single-variable statistics (SD Mode), if the statistical graph drawing type (STAT GRAPH) is set to "DRAW," the clear operation clears bar graph memory θ.

■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 a result.

Example 1 $2+3-4+10=$

[AC][2][+][3][−][4][+][1][0][EXE]

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

Example 2 $2(5+4)\div(23\times5)=$

[AC][2][(][5][+][4][)][÷]
[(][2][3][×][5][)][EXE]

```
2(5+4)÷(23×5)
      0.15652173913
```

The unit uses two types of functions: Type A functions and Type B functions. With Type A functions, you press the function key after you enter a value. With Type B functions, you press the function key first and then enter a value.

Example 1 **(Type A function)**

	Example	Key Operation
Squares:	4^2	[4][x^2]

Example 2 **(Type B function)**

	Example	Key Operation
Sine:	2 sin45°	[2][sin][4][5]

- For detailed examples on all of the possible calculations available, see the section titled "Calculation Priority Sequence" on page 51.

• To clear an entire calculation and start again

Press the [AC] key to clear the error along with the entire calculation. Next, re-input the calculation from the beginning.

■Editing Calculations

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

• To change a step

Example **To change cos60 to sin60**

[cos][6][0]

```
cos 60_
```

◀◀◀

```
cos 60
```

sin

```
sin 60
```

• To delete a step

Example To change 369 × × 2 to 369 × 2

3 6 9 × × 2

```
369××2_
```

◀◀ DEL

```
369×2
```

• To insert a step

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

2 • 3 6 x^2

```
2.36²_
```

◀◀◀◀◀

```
2.36²
```

SHIFT INS

```
2.36²
```

sin

```
sin 2.36²
```

•When you press SHIFT INS a space is indicated by the symbol "␣". The next function or value you input is inserted at the location of "␣". To abort the insert operation without inputting anything, move the cursor, press SHIFT INS again, or press EXE.

• To make corrections in the original calculation

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

AC 1 4 ÷ 0 ×
2 • 3 EXE

```
14÷0×2.3
Ma  ERROR
Bytes  4
```

Press ◀ or ▶.

```
14÷0×2.3
```

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

Make necessary changes.
◀ SHIFT INS 1

```
14÷10×2.3
```

Execute it again.
EXE

```
14÷10×2.3
          3.22
```

•The last calculation performed is not cleared even when you press the AC key. This means you can clear the display using AC and then recall the calculation.
•The last calculation performed is cleared whenever you press the EXE key to select a mode in the Main Menu.

■ Answer Function

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

• To recall the contents of the answer memory

SHIFT Ans EXE

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

Example 123 + 456 = 579
789 − 579 = 210

AC 1 2 3 + 4 5 6 EXE

```
123+456
          579
```

7 8 9 − SHIFT Ans EXE

```
789-Ans
          210
```

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

■ 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 three 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.

•Newline Operation

The newline operation ends the line you are currently inputting, and moves the cursor to the next line. When execution reaches the end of a line where a newline operation was performed, the unit treats the end of the line like a colon (multistatement connector).

• To use multistatements

Example 6.9×123=848.7
123÷3.2=38.4375

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

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

Appears on display when "◢" is used.

[EXE]

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

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

Example 123×456:×5
Invalid

■Multiplication Operations without a Multiplication Sign

You can omit the multiplication sign (×) in any of the following operations.
•Before the type B functions (page 52)

Example 2sin30, 10log1.2, 2√3, 2pol(5, 12), etc.

•Before constants, variable names, value memory names

Example 2π, 2AB, 3Ans, 3Y1, 4Sim X, etc.

•Before an open parenthesis

Example 3(5+6), (A+1)(B−1), etc.

■Performing Continuous Calculations

The unit lets you use the result of one calculation as one of the arguments in the next calculation. The precision of such calculations is 12 digits (for the mantissa).

Example 1÷3=
1÷3×3=

[AC][1][÷][3][EXE]

```
1÷3
          0.333333333333
```

(Continuing)
[×][3][EXE]

```
Ans×3
                        1
```

Continuous calculations can also be used with Type A functions (see page 51).

■Using the Replay Function

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

Example **To perform the following two calculations**
4.12×3.58+6.4=21.1496
4.12×3.58−7.1=7.6496

[AC][4][•][1][2][×]
[3][•][5][8][+][6][•][4][EXE]

```
4.12×3.58+6.4
                  21.1496
```

[◀]

```
4.12×3.58+6.4_
```

[◀][◀][◀][◀][−][7][•][1][EXE]

```
4.12×3.58−7.1
                   7.6496
```

•The maximum capacity of the replay memory is 127 bytes.
•The contents of the replay memory are not cleared when you press the [AC] key, so you can recall a calculation and execute it even after performing the all clear operation. Note, however, that replay memory contents are cleared whenever you change to another mode or menu.

•After you press [AC], you can press ▲ or ▼ to recall previous calculations (up to 256 bytes), in sequenced from the newest to the oldest (Multi-Replay Function). Once you recall a calculation, you can use ▶ and ◀ to move the cursor around the calculation and make changes in it to create a new calculation. Note, however, that multi-replay memory contents are cleared whenever you change to another menu, or when you enter the STAT DATA Mode (STO or NON-STO).

■Built-in Scientific Functions

In addition to the scientific functions that you can access directly from the keyboard, this calculator also provides a selection of other built-in functions. Use the MATH Menu to access these built-in functions.

• To call up the MATH Menu

[SHIFT] [MATH]

Press the function key to call up the sub-menu that contains the type of operation you want to perform.

- [F1](HYP) ..... Hyperbolic Function Menu for hyperbolic and inverse hyperbolic functions
- [F2](PRB) ..... Probability Function Menu for factorials, permutations, combinations, random numbers, and Σ calculations
- [F3](NUM) ..... Numeric Function Menu for absolute value calculations, integer and decimal part extractions, and internal rounding
- [F4](DMS) ..... Sexagesimal Function Menu for degree, minute, second inputs and conversions
- [F5](CORD) ..... Coordinate Function Menu for rectangular and polar coordinate transformations
- [F6](ESYM) ..... Engineering Symbol Menu for engineering symbols

• To use the Hyperbolic Function Menu

[SHIFT] [MATH]

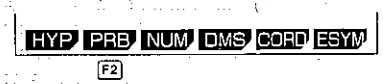
[F1](HYP)

Press the function key below the hyperbolic function you want to input.

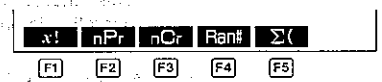
- [F1](sinh) ..... hyperbolic sine
- [F2](cosh) ..... hyperbolic cosine
- [F3](tanh) ..... hyperbolic tangent
- [F4](sinh^{-1}) ..... inverse hyperbolic sine
- [F5](cosh^{-1}) ..... inverse hyperbolic cosine
- [F6](tanh^{-1}) ..... inverse hyperbolic tangent

• To use the Probability/Σ Function Menu

[SHIFT] [MATH]



[F2](PRB)



Press the function key below the probability function you want to input.

- [F1]($x!$) ..... factorial of x
- [F2](nPr) ..... permutation
- [F3](nCr) ..... combination
- [F4](Ran #) ..... random number generation
- [F5](Σ( ) ..... Σ (sigma) calculations (page 81)

• To use the Numeric Function Menu

[SHIFT] [MATH]

[F3](NUM)

Press the function key below the numeric function you want to input.

- [F1](Abs) ..... absolute value
- [F2](Int) ..... integer extraction
- [F3](Frac) ..... fraction extraction
- [F4](Rnd) ..... rounding*
- [F5](Intg) ..... maximum value that does not exceed argument

*Rounds the internal value to 12 significant digits. The same rounding is applied to the Ans memory contents. In the Fix mode, the internal value is cut off in accordance with the Fix specification. In the Sci mode, the internal value is cut off so the number of significant digits is in accordance with the Sci mode specification.

• To use the Sexagesimal Function Menu

[SHIFT] [MATH]

[F4](DMS)

Press the function key below the sexagesimal function you want to input.

F1(° ' ") ..... For input of hours, minutes and seconds, or degrees, minutes and seconds as sexagesimal values

F2(°.....) ..... For input of hours, minutes and seconds, or degrees, minutes and seconds as decimal values*

*This function menu item appears only when the result of an operation is on the display.

• To use the Coordinate Function Menu

SHIFT MATH

F5(CORD)

Press the function key below the coordinate function you want to input.

F1(Pol ( ) ..... transformation of rectangular coordinates to polar coordinates

F2(Rec ( ) ..... transformation of polar coordinates to rectangular coordinates

• To use the Engineering Symbol Menu

SHIFT MATH

F6(ESYM)

Press the function key below the engineering symbol you want to input.

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

F2(μ) ..... micro (10^{-6})

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

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

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

F6(▽) ..... advance to next menu

F6(▽)

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

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

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

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

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

F6(E) ..... exa (10^{18})

•Engineering symbols cannot be used inside of multistatements or programs.

• To use engineering symbols in calculations

Example **1000 m×5 k**

AC 1 0 0 0 SHIFT MATH
F6(ESYM)F1(m) × 5
F6(▽)F1(k)EXE

■Value Memories

This calculator comes with 28 value memories as standard (which can be expanded up to 2428). You can use value memories to store values to be used inside of calculations. Value memories 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 value memories is 15 digits for the mantissa and 2 digits for the exponent. Value memory contents are retained even when you switch power off.

Important

•Some value memories are used by the unit for certain types of calculations. Note the following.

Type of Calculation	Value Memories Used
Single-Variable Statistics (non-storage)	U, V, W
Paired-Variable Statistics (non-storage)	P, Q, R, U, V, W
Differentiation	F, G, H
Integration	K, L, M, N
Coordinate Conversion	I, J

You cannot assign values to these value memories while the above calculations are being performed. You should also clear the value memories before starting the above operations. Be especially careful during programmed calculations to avoid problems caused by values mistakenly assigned to memories that are used by the calculator.

• To assign a value to a value memory

Example **To assign 123 to value memory A**

AC 1 2 3 → ALPHA A EXE

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

AC ALPHA A + 4 5 6
→ ALPHA B EXE

• To display the contents of a value memory

Example To display the contents of value memory A

AC ALPHA A EXE

```
A
                123
```

• To clear a value memory

Example To clear value memory A

AC 0 → ALPHA A EXE

```
0→A
                0
```

• To clear all value memory contents

AC SHIFT CLR F1 (Mcl) EXE

```
Mcl
                0
```

■Increasing the Number of Value Memories

Though 28 value memories are provided as standard, you can configure the memory of the unit to increase the number of value memories and decrease the amount of program memory. Each additional value memory takes up ten bytes of program memory.

Number of Value Memories	28	29	30	·····	2428
Number of Program Memory Bytes	24000	23990	23980	·····	0

The maximum number of value memories possible is 2428 (an increase of 2400).

Important

- You may not be able to increase the number of value memories to the level you want if the memory already contains programs, matrices, function memory contents, or statistical data. If there is not enough unused memory available to increase to the number you specify, an error message will appear on the display.
- The SHIFT Defm specification can also be included within a program.

• To increase the number of value memories

Example To increase the number of value memories by 30 (for a total of 28 + 30 = 58)

SHIFT Defm 3 0 EXE

```
①→ PRGM:    0 FUNC:    0 ←⑧
②→ EDTR:    0 RECR:    0 ←⑨
③→ FMEM:    0 DYNA:   65 ←⑩
④→ MAT  :   0 SIML:    0 ←⑪
⑤→ SD   :   0 POLY:    0 ←⑫
⑥→ REG  :   0 GRPH:    0 ←⑬
⑦→ MEM  :  58 Free:23700 ←⑭
```

① Number of bytes used for program storage
② Number of bytes used for file storage
③ Number of bytes used for function memory storage
④ Number of bytes used for matrix storage
⑤ Number of bytes used for single-variable statistical data storage
⑥ Number of bytes used for paired-variable statistical data storage
⑦ Number of value memories currently available
⑧ Number of bytes used by Table & Graph function storage
⑨ Number of bytes used by Table & Graph for recursion formula storage
⑩ Number of bytes used for Dynamic Graph formula storage
⑪ Number of bytes used for linear equation storage
⑫ Number of bytes used for quadratic and cubic equation storage
⑬ Number of bytes used for graph function storage
⑭ Number of bytes remaining

• To check the current memory status

SHIFT Defm EXE (or hold down M Disp)

• To initialize the number of value memories

SHIFT Defm 0 EXE

```
PRGM:    0 FUNC:    0
EDTR:    0 RECR:    0
FMEM:    0 DYNA:   65
MAT  :   0 SIML:    0
SD   :   0 POLY:    0
REG  :   0 GRPH:    0
MEM  :  28 Free:24000
```

■About Memory Names

You can use the additional memories you create from program memory just as you use the original 28. The names of the additional memories are Z[1], Z[2], Z[3], etc. If you increase the number of value memories by 5, you can access the original 28 memories, plus memories Z[1] through Z[5].

1-5 Using the Function Memory

You can store up to six functions in memory for instant recall when you need them. Function memory can be used in any mode except the BASE Mode.

• To display the Function Memory Menu

[SHIFT] [F:MEM]

```
STO RCL fn LIST
F1  F2  F3  F4
```

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- [F1](STO) ..... Stores functions
- [F2](RCL) ..... Recalls functions
- [F3](fn) ..... Specifies input as a function. See page 216 for an example of [F3](fn) operation.
- [F4](LIST) ..... Displays a list of stored functions

• To store a function

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

[SHIFT] [F:MEM]
[AC] [(] [ALPHA] [A] [+] [ALPHA] [B] [)]
[(] [ALPHA] [A] [−] [ALPHA] [B] [)]

```
(A+B)(A−B)_
```

```
STO RCL fn LIST
F1
```

[F1](STO)

```
STO RCL fn LIST
```

[1]

```
== FUNCTION MEMORY ==
f1:(A+B)(A−B)
```

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

• To recall a function

Example **To recall function memory number 1**

[SHIFT] [F:MEM]

```
STO RCL fn LIST
F2
```

[F2](RCL)

```
STO RCL fn LIST
```

[1]

```
(A+B)(A−B)_
```

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

• To display a list of available functions

[SHIFT] [F:MEM]

```
STO RCL fn LIST
F4
```

[F4](LIST)

```
== FUNCTION MEMORY ==
f1:(A+B)(A−B)
f2:
f3:
f4:
f5:
f6:
STO RCL fn LIST
```

• To delete a function

Example **To delete function memory number 1**

[SHIFT] [F:MEM] [AC] [F1](STO)

```
STO RCL fn LIST
```

[1]

```
== FUNCTION MEMORY ==
f1:
```

•Executing the store operation while the display is blank deletes the function for the Function Memory you specify.

■Variable Data (VAR) Menu

The VAR menu lets you recall the following types of data.

- **Graph ranges**
- **Zoom factor ratios**
- **Graph functions**
- **Statistical data (using the STO Mode)**
- **Linear equation coefficients and solutions**
- **Quadratic equation coefficients and solutions**
- **Cubic equation coefficients and solutions**
- **Table & Graph table ranges and table contents**

• To display the VAR Menu

[SHIFT][VAR]

The following are the data types that can be selected from the function menu at the bottom of the display. Press the function key below the data type you want to specify.

[F1](RANG) ..... Graph range data (page 146)
[F2](FACT) ..... Zoom factor data (page 203)
[F3](GRPH) ..... Graph function data (page 169)
[F4](STAT) ..... Statistical data* (page 90)
[F5](EQUA) ..... Linear, quadratic, and cubic equation data (page 136)
[F6](TABL) ..... Table & Graph data (page 242)

*This function menu item appears only when STO is specified in the Statistical Data Storage (STAT DATA) Mode set up display (page 22).

• To recall graph range data

[SHIFT][VAR][F1](RANG)

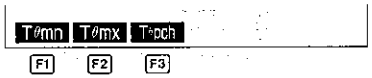
Press the function key below the data type you want to recall.

[F1](Xmin) ..... x-axis minimum
[F2](Xmax) ..... x-axis maximum
[F3](Xscl) ..... x-axis scale
[F4](▽) ..... advance to next range data menu

[F4](▽)

[F1](Ymin) ..... y-axis minimum
[F2](Ymax) ..... y-axis maximum
[F3](Yscl) ..... y-axis scale
[F4](▽) ..... advance to next range data menu

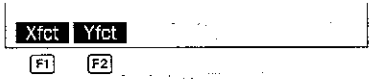
[F4](▽)



[F1](Tθmn) ..... T, θ minimum
[F2](Tθmx) ..... T, θ maximum
[F3](Tθpch) ..... T, θ pitch

• To recall zoom factor data

[SHIFT][VAR][F2](FACT)

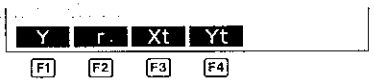


Press the function key below the data type you want to recall.

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

• To recall a graphic function

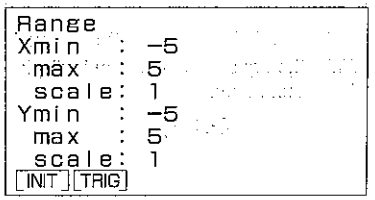
[SHIFT][VAR][F3](GRPH)



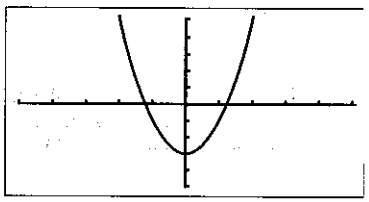
Press the function key below the data type you want to recall.

[F1](Y) ..... Press [F1] before inputting a value that identifies a rectangular coordinate graph function.
[F2](r) ..... Press [F2] before inputting a value that identifies a polar coordinate graph function.
[F3](Xt) ..... Press [F3] before inputting a value that identifies an Xt parametric graph function.
[F4](Yt) ..... Press [F4] before inputting a value that identifies an Yt parametric graph function.

Example **To recall that rectangular function $y=2x^2-3$, which is stored in memory location Y2 using the following range parameters (page 169):**



[Graph] [SHIFT] [VAR]
[F3](GRPH)[F1](Y)[2][EXE]



• To recall statistical data

[SHIFT] [VAR] [F4](STAT)

Press the function key below the data type you want to recall.

[F1](DTx) ..... Single-variable or paired-variable x-data
[F2](DTy) ..... Single-variable or paired-variable y-data*
[F3](DTf) ..... Single-variable or paired-variable number of data items

*This function menu item appears only in the Regression Mode (page 97).

• To recall equation coefficient and solution data

[SHIFT] [VAR] [F5](EQUA)

Press the function key below the data type you want to recall.

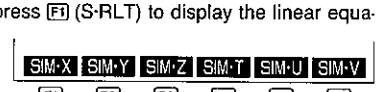
[F1](S·RLT) ..... Linear equation (2 to 6 unknowns) solution data
[F2](S·COF) ..... Linear equation (2 to 6 unknowns) coefficient data*
[F3](P·RLT) ..... Quadratic and cubic equation solution data
[F4](P·COF) ..... Quadratic and cubic equation coefficient data*

*These function menu items appear only in the Matrix Mode (page 112).

• To recall linear equation solution data

While the equation data menu is displayed, press [F1] (S·RLT) to display the linear equation result menu.

[F1](S·RLT)



Press the function key below the data type you want to recall.

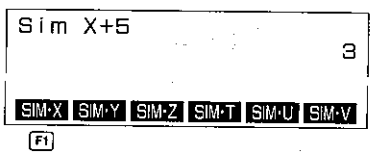
[F1](SIM·X) ..... Solution x for linear equation with two to six unknowns*
[F2](SIM·Y) ..... Solution y for linear equation with two to six unknowns*
[F3](SIM·Z) ..... Solution z for linear equation with three to six unknowns
[F4](SIM·T) ..... Solution t for linear equation with four to six unknowns
[F5](SIM·U) ..... Solution u for linear equation with five or six unknowns
[F6](SIM·V) ..... Solution v for linear equation with six unknowns

*Memory data for linear equations with two to six unknowns cannot be recalled on the same display.

Example **To add five to solution x for the following linear equations with two unknowns (page 137):**

$2x + 3y = 8$
$3x + 5y = 14$

[F1](S·RLT)
[F1](SIM·X) [+] [5]
[EXE]



• To recall linear equation coefficient data

While the equation data menu is displayed, press [F2](S·COF)[EXE] to display a matrix of coefficients. Note that the recalled coefficients are also stored in the Matrix Answer Memory (Mat Ans).

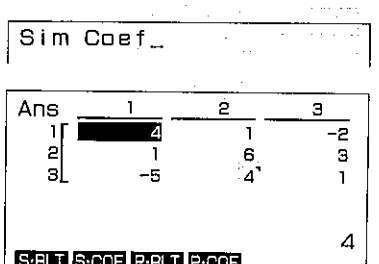
•The above operation produces an error (Mem ERROR) if there is no linear equation coefficient data to recall.

Example **To recall the coefficients for the following linear equations with three unknowns (page 137):**

$4x + y - 2z = -1$
$x + 6y + 3z = 1$
$-5x + 4y + z = -7$

[F2](S·COF)

[EXE]

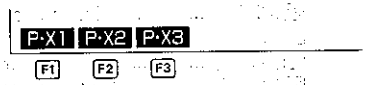


A313043-2

• To recall quadratic and cubic equation solution data

While the equation data menu is displayed, press [F3] (P·RLT) to display the quadratic cubic equation result menu.

[F3](P·RLT)

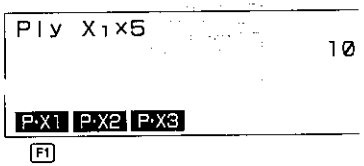


Press the function key below the data type you want to recall.

[F1](P·X1) ..... Solution X_1 for a quadratic or cubic equation
[F2](P·X2) ..... Solution X_2 for a quadratic or cubic equation
[F3](P·X3) ..... Solution X_3 for a cubic equation

Example **To multiply solution X_1 for the following quadratic equation by 5 (page 140):**
$2x^2 + x - 10 = 0$

[F3](P·RLT)
[F1](P·X1)[×][5]
[EXE]



• To recall quadratic and cubic equation coefficient data

While the equation data menu is displayed, press [F4](P·COF)[EXE] to display a matrix o coefficients. Note that the recalled coefficients are also stored in the Matrix Answer Memor (Mat Ans).

• The above operation produces an error (Mem ERROR) if there is no quadratic or cubi equation coefficient data to recall.

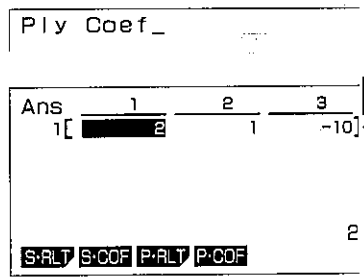
Important

The above operation can be performed in the Matrix Mode only.

Example **To recall the coefficients for the following quadratic equation (page 140)**
$2x^2 + x - 10 = 0$

[F4](P·COF)

[EXE]



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

While the variable data menu is displayed, press [F6](TABL) to display the Table & Graph data menu.

[SHIFT][VAR][F6](TABL)

Press the function key below the data type you want to recall.

[F1](FRNG) ..... Function table range data
[F2](F.RSLT) ..... Function table content data*
[F3](RRNG) ..... Recursion table range data
[F4](R.RSLT) ..... Recursion table content data*

*These function menu items appear only in the Matrix Mode (page 112).

• To recall function/recursion table range data

While the Table & Graph data menu is displayed, press [F1] (FRNG) to display the function table range data menu or [F3] (RRNG) to display the recursion table range data menu.

[F1](FRNG)
(or [F3](RRNG))

Press the function key below the data type you want to recall.

[F1](FStrt) ..... Variable X start value
[F2](FEnd) ..... Variable X end value
[F3](FPich) ..... Variable X pitch*

*This function menu item appears only for function table range data (when you press [F1] (FRNG)).

• To recall function/recursion table content data

While the Table & Graph data menu is displayed, press [F2] (F·RSLT) to display the table contents. Note that the recalled coefficients are also stored in the Matrix Answer Memory (Mat Ans).

• The above operation produces an error (Dim ERROR) if there is no function/recursion table data to recall.

Important

The above operation can be performed in the Matrix Mode only.

Example **To display the table contents for the following function.**
$y = 3x^2 - 2$
Use the following table range parameters (page 242).
Start = 0, End = 6, Pitch = 1

[F2](F-RSLT)

[EXE]

```
F Result_
```

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

Ø

F-RNG F-RSLT R-RNG R-RSLT

1-6 Using the BASE Mode

You can use the BASE Mode to perform calculations with binary, octal, decimal and hexadecimal values. You should also use this mode to convert between number systems and for logical operations.

- You cannot use scientific functions in the BASE Mode.
- You can use only integers in the BASE Mode, so fractional values are not allowed. If you input a value that includes a decimal part, the unit automatically cuts off the decimal.
- If you attempt to enter a value that is invalid in the number system (binary, octal, decimal, hexadecimal) you are using, the calculator displays an error message. The following shows the numerals that can be used in each number system.
  - Binary: 0, 1
  - Octal: 0, 1, 2, 3, 4, 5, 6, 7
  - Decimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
  - Hexadecimal: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F
- The alphabetic characters used in the hexadecimal number appear differently on the display to distinguish them from text characters.
  - Normal Text: A, B, C, D, E, F
  - Hexadecimal Values: 𝖠, 𝖡, 𝖢, 𝖣, 𝖤, 𝖥
- Negative binary, octal, and hexadecimal values are produced using the two's complement of the original value.
- The following are the display capacities for each of the number systems.

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

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

Calculation Ranges in BASE Mode
Binary Values
- Negative : $1000000000000000 \leqq x \leqq 1111111111111111$
- Positive : $0 \leqq x \leqq 1111111111111111$

Octal Values
- Negative : $20000000000 \leqq x \leqq 37777777777$
- Positive : $0 \leqq x \leqq 17777777777$

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

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

• To enter the BASE Mode

Highlight the **BASE** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the BASE Mode.

[EXE]

Main BASE Mode screen

```
RUN    /BASE-N
          DEC
M-D/Cpy : M-Disp
```

Dec Hex Bin Oct d~o LOG

[F1] [F2] [F3] [F4] [F5] [F6]

The following are the number systems that are available.

- [F1](Dec) ..... decimal
- [F2](Hex) ..... hexadecimal
- [F3](Bin) ..... binary
- [F4](Oct) ..... octal
- [F5](d~o) ..... Number system specification menu
- [F6](LOG) ..... Logical operation menu

• To set the default BASE Mode number system

Example **To set the default BASE Mode number system to decimal**

[F1](Dec)[EXE]

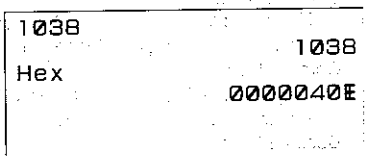
```
Dec
                    Ø
```

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

Example To convert $1{,}038_D$ (default number system) to its hexadecimal value

AC 1 0 3 8 EXE

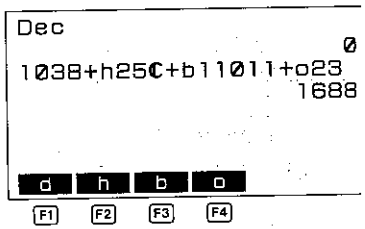
F2(Hex) EXE



• To input values of mixed number systems

Example To input $1{,}038_D + 25C_H + 11011_B + 23_O$, when the default number system is decimal

AC F1(Dec) EXE
1 0 3 8 + F5(d ~ o) F2(h)
2 5 C + F3(b) 1 1
0 1 1 + F4(o) 2 3 EXE



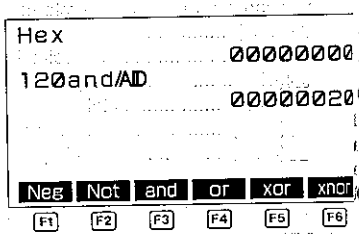
The following are the types of values that can be specified in the above menu.

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

• To input logical operations

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

AC F2(Hex) EXE
1 2 0 F6(LOG) F3(and)
A D EXE



The following are the logical operations that can be input from the above menu.

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

1-7 Graphic and Text Displays

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

• To switch between the graphic display and text display

Press the G↔T key. You should also note that the key operations used to clear each type of display are different.

• To clear the graphic display

Press SHIFT F5(Cls) EXE.

• To clear the text display

Press AC.

Pressing AC while a graphic display is shown switches to a cleared text display. Note that this does not apply in the case of the Dynamic Graph display.

1-8 Technical Information

This section provides information on the internal workings of the unit.

■ 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, integrations, Σ calculations
d/dx, $\int dx$, Σ
② Type A functions
With these functions, the value is entered and then the function key is pressed.
x^2, x^{-1}, $x!$, °' ", ENG symbols
③ Power/root
$\wedge(x^y)$, $\sqrt[x]{\ }$

④Fractions
$a^b/_c$

⑤Abbreviated multiplication format in front of π, memory name, or variable name
recursions
2π, 5A, 3Sim X, X min, F Start, a_{n+1}, etc.

⑥Type B functions
With these functions, the function key is pressed and then the value is entered.
$\sqrt{}$, $\sqrt[3]{}$, log, ln, e^x, 10^x, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, sinh^{-1}, cosh^{-1}, tanh^{-1}, (−), parenthesis, (following in BASE Mode only) d, h, b, o, Neg, Not (also Mat, Det, Trn in the MAT Mode only)

⑦Abbreviated multiplication format in front of Type B functions
2√3, A log2, etc.

⑧Permutation, combination
$_nP_r$, $_nC_r$

⑨×, ÷

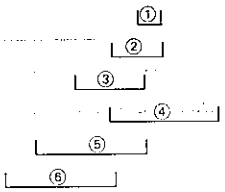
⑩+, −

⑪and
⑫or, xor, xnor
] BASE Mode only

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

•Anything contained within parentheses receives highest priority.

Example **$2+3\times(\log \sin 2\pi^2 + 6.8) = 22.0710169099$ (in the "Rad" mode)**

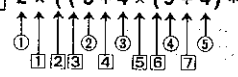


■Stacks

The unit employs memory blocks, called *stacks*, for storage of low priority values and commands. There is a 10-level *numeric value stack*, a 26-level *command stack*, and a 10-level *program subroutine stack*. If you execute a formula so complex it exceeds the amount of stack space available, an error message appears on the display (Stk ERROR during calculations or Ne ERROR during execution of a program subroutine).

```
Stk  ERROR
 Bytes     26
```


Example **$2\times((3+4\times(5+4)+3)\div5)+8=$**



Numeric Value Stack

①	2
②	3
③	4
④	5
⑤	4
⋮	

Command Stack

1	×
2	(
3	(
4	+
5	×
6	(
7	+
⋮	

•Calculations are performed according to the priority sequence described on page 51. 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 (page 54) takes up two command stack levels.

■Value Input and Output Limitations

The allowable range for both input and output values is 12 digits for the mantissa and 2 digits for the exponent. Internally, however, the unit performs calculations using 15 digits for the mantissa and 2 digits for the exponent.

Example **$3\times10^5\div7-42857=$**

AC 3 EXP 5 ÷ 7 EXE

3 EXP 5 ÷ 7 − 4 2 8 5 7 EXE

```
3E5÷7
          42857.1428571
3E5÷7-42857
          0.1428571428
```

•Calculation results that are greater than 10^{10} (10 billion) or less than 10^{-2} (0.01) are automatically displayed in exponential form.
•Values are stored in memory with 15 digits for the mantissa and 2 digits for the exponent.

■Input Capacity

This unit has a 127-byte area for execution of calculations. Each time you press a numeric key or arithmetic operation key, one byte of memory is used. In addition, the following functions take up two bytes each:

- d/dx (, Σ (
- Mat, Det, Trn (in the MAT Mode)
- ∗ROW, ∗ROW+, ROW+, Swap (in the PRGM-MAT Mode)
- Y, r, Xt, Yt, Sim X, Sim Y, Sim Z, Sim T, Sim U, Sim V, Sim Coef, Ply X_1, Ply X_2 Ply X_3, Ply Coef (in the VAR Mode)
- Xmin, Xmax, Xscl, Ymin, Ymax, Yscl, Tθmin, Tθmax, Tθptch, Xfct, Yfct, DTx, DTy DTf (in the VAR Mode)
- F Result, F Start, F End, F Pitch, R Result, R Start, R End, R Pitch (in the VAR Mode)
- i, Arg, Conjg, ReP, ImP, (in the CMPLX Mode)
- a_n, a_{n+1}, a_{n+2}, n, a_0, a_1, a_2 (in the TABLE-RECR Mode)

A calculation can consist of up to 127 bytes. Whenever you input the 121st byte of an calculation, the cursor changes from "_" to "■" on the display to let you know that you are running out of memory. If you still need to input more, you should divide your calculation into two or more parts.

Note

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

■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 $\pm 9.99999999999 \times 10^{99}$ (Ma ERROR)
- When an attempt is made to perform a function calculation that exceeds the input range (Ma ERROR) (see page 335)
- When an illegal operation is attempted during statistical calculations (Ma ERROR) For example, attempting to obtain $\bar{x}$ or $x\sigma n$ without data input.
- When the capacity of the numeric value stack or command stack is exceeded (Stk ERROR) For example, entering 25 successive (, followed by 2+3×4=.
- When an attempt is made to perform a calculation using an illegal formula (Syn ERROR) For example, 5××3=.
- When an illegal memory specification is made (Mem ERROR)
- When an illegal command or function argument is used (Arg ERROR)
- When an attempt is made to use an illegal dimension during matrix calculations (Dim ERROR)

Notes

- Other errors can occur during program execution. See page 332 for details. Most of the calculator's keys are inoperative while an error message is displayed. You can resume operation using one of the two following procedures.
- Press the AC key to clear the error and return to normal operation.
- Press ◀ or ▶ to display the error (see page 30).

■Exponential Display

During normal calculation, the unit is capable of displaying up to 12 digits. Values that exceed this limit, however, are automatically displayed in exponential format. You can choose between 2 different types of exponential display formats.

Norm 1: $10^{-2}(0.01) > |x|, |x| \geqq 10^{12}$

Norm 2: $10^{-11}(0.00000000001) > |x|, |x| \geqq 10^{12}$

You can select between Norm 1 and Norm 2 using the Display Mode (page 26). Pressing MODE displays the current mode settings.

AC 1 ÷ 200 =

```
1÷200
                5.E-03
```

(Norm 1 display format)

```
1÷200
                0.005
```

(Norm 2 display format)

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

How to interpret exponential format

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

Mantissa Exponent

➡ 1.2×10^{12} ➡ 1,200,000,000,000

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, since the exponent is positive. This results in the value 1,200,000,000,000.

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

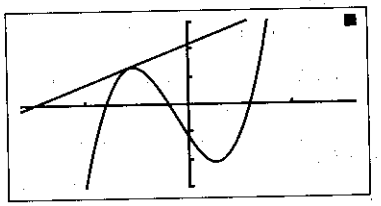
Mantissa Exponent

➡ 1.2×10^{-3} ➡ 0.0012

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, since the exponent is negative. This results in the value 0.0012.

■Calculation Execution Display

When 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 indicates that the calculator is performing an internal operation.



■When Errors Keep Occurring...

If you find that errors keep occurring when you try to perform an operation, use the following procedure to bring the calculator back to its initial settings and try again.

(1) Use the Main Menu to enter the COMP Mode.
(2) Press [SHIFT] [ORG] to display the menu for setting the unit of angular measurement, and then press [F1] (Deg) [EXE] to specify degrees.
(3) Press [SHIFT] [DISP] to display the display format setting, and then press [F3](Norm)[EXE] to enter the Norm 1 Mode.

Chapter 2

Manual Calculations

Chapter 2 Manual Calculations

Manual calculations are those that you input manually, as on the simplest of calculators. They are to be distinguished from programmed calculations. This chapter provides various examples to help you become familiar with the manual calculation capabilities of the unit.

2-1 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 display is rounded to a 12-digit mantissa before it is displayed.

Example	Operation	Display
$23+4.5-53=-25.5$	23 + 4.5 − 53 EXE	−25.5
$56\times(-12)\div(-2.5)=268.8$	56 × (-) 12 ÷ (-) 2.5 EXE	268.8
$12369\times7532\times74103=6.90368061272\times10^{12}$ (6903680612720)	12369 × 7532 × 74103 EXE	6.90368061272E+12
$(4.5\times10^{75})\times(-2.3\times10^{-79})=-1.035\times10^{-3}$ (-0.001035)	4.5 EXP 75 × (-) 2.3 EXP (-) 79 EXE	−1.035E-03 (Norm 1 display format)
$(2+3)\times10^{2}=500$	(2 + 3) × 1 EXP 2 EXE	500

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

$(1\times10^{5})\div7=14285.7142857$	1 EXP 5 ÷ 7 EXE	14285.7142857
$(1\times10^{5})\div7-14285=0.7142857142$	1 EXP 5 ÷ 7 − 14285 EXE	0.7142857142

- For mixed arithmetic calculations, multiplication and division are given priority over addition and subtraction.

Example	Operation	Display
$3+5\times6=33$	3 + 5 × 6 EXE	33
$7\times8-4\times5=36$	7 × 8 − 4 × 5 EXE	36
$1+2-3\times4\div5+6=6.6$	1 + 2 − 3 × 4 ÷ 5 + 6 EXE	6.6

■Calculations Using Parentheses

Example	Operation	Display
$100-(2+3)\times4=80$	100 − (2 + 3) × 4 EXE	80
$2+3\times(4+5)=29$	2 + 3 × (4 + 5 EXE	29

- The final closed parentheses (immediately before operation of the EXE key) may be omitted, no matter how many are required.

$(7-2)\times(8+5)=65$	(7 − 2) (8 + 5 EXE	65

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

$10-\{2+7\times(3+6)\}=-55$	10 − (2 + 7 × (3 + 6 EXE	−55

- In this manual, the multiplication sign is always shown.

$\frac{2\times3+4}{5}=(2\times3+4)\div5=2$	(2 × 3 + 4) ÷ 5 EXE	2
$\frac{5\times6+6\times8}{15\times4+12\times3}=0.8125$	(5 × 6 + 6 × 8) ÷ (15 × 4 + 12 × 3) EXE	0.8125
$(1.2\times10^{19})-\{(2.5\times10^{20})\times\frac{3}{100}\}=4.5\times10^{18}$	1.2 EXP 19 − (2.5 EXP 20 × 3 ÷ 100) EXE	4.5E+18
$\frac{6}{4\times5}=0.3$	6 ÷ (4 × 5) EXE	0.3

- The above is identical to 6 ÷ 4 ÷ 5 EXE.

2-2 Units of Angular Measurement

- See page 25 for full details on specifying the unit of angular measurement.
- Once you specify a unit of angular measurement, it remains in effect until you specify a different one. The specification is retained even if you switch power off.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
Result displayed in degrees. To convert 4.25 rad to degrees.	SHIFT DRG F1(Deg) EXE 4.25 F5(r) EXE	243.507062931
47.3° + 82.5rad = 4774.20180983°	47.3 + 82.5 F5(r) EXE	4774.20180983

2-3 Trigonometric and Inverse Trigonometric Functions

- Be sure to set the unit of angular measurement before performing trigonometric function and inverse trigonometric function calculations.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
sin 63°52′41″ = 0.8978590111961	SHIFT DRG F1(Deg) EXE sin 63 SHIFT MATH F4(DMS) F1(° ′ ″) 52 F1(° ′ ″) 41 F1(° ′ ″) EXE	0.8978590111961
$\cos\left(\frac{\pi}{3}\text{rad}\right) = 0.5$	SHIFT DRG F2(Rad) EXE cos (SHIFT π ÷ 3) EXE	0.5
tan(−35gra) = −0.61280078814	SHIFT DRG F3(Gra) EXE tan (−) 35 EXE	−0.61280078814
2·sin 45° × cos 65° = 0.59767247746	SHIFT DRG F1(Deg) EXE 2 × sin 45 × cos 65 EXE (× can be omitted.)	0.59767247746
$\cot 30° = \frac{1}{\tan 30°}$ = 1.73205080757	1 ÷ tan 30 EXE	1.73205080757

2-4 Logarithmic and Exponential Functions

- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
log 1.23 ($\log_{10}1.23$) = $8.99051114394 \times 10^{-2}$	log 1.23 EXE	0.0899051114394
ln90 (log90) = 4.49980967033	ln 90 EXE	4.49980967033
$10^{1.23} = 16.9824365246$ (To obtain the antilogarithm of common logarithm 1.23)	SHIFT 10^x 1.23 EXE	16.9824365246
$e^{4.5} = 90.0171313005$ (To obtain the antilogarithm of natural logarithm 4.5)	SHIFT e^x 4.5 EXE	90.0171313005
$10^4 \cdot e^{-4} + 1.2 \cdot 10^{2.3}$ = 422.587866684	SHIFT 10^x 4 × SHIFT e^x (−) 4 + 1.2 × SHIFT 10^x 2.3 EXE	422.587866684
$(-3)^4 = (-3) \times (-3) \times (-3) \times (-3) = 81$	((−) 3) $\wedge$ 4 EXE	81
$-3^4 = -(3 \times 3 \times 3 \times 3) = -81$	(−) 3 $\wedge$ 4 EXE	−81
$5.6^{2.3} = 52.581438372$	5.6 $\wedge$ 2.3 EXE	52.581438372
$\sqrt[7]{123}$ $(= 123^{\frac{1}{7}})$ = 1.98864779528	7 SHIFT $\sqrt{\ }$ 123 EXE	1.98864779528

2-5 Hyperbolic and Inverse Hyperbolic Functions

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
$\sinh 3.6 = 18.2854553606$	SHIFT MATH F1(HYP) F1(sinh) 3.6 EXE	18.2854553606
$\cosh^{-1}\left(\frac{20}{15}\right) = 0.795365461224$	SHIFT MATH F1(HYP) F5($\cosh^{-1}$) (20 ÷ 15) EXE	0.795365461224
Determine the value of x when $\tanh 4x = 0.88$ $x = \frac{\tanh^{-1} 0.88}{4}$ $= 0.34394191413$	SHIFT MATH F1(HYP) F6($\tanh^{-1}$) 0.88 ÷ 4 EXE	0.34394191413

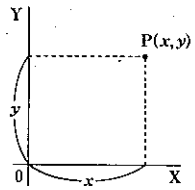
2-6 Other Functions

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
$\sqrt{2}+\sqrt{5} = 3.65028153987$	SHIFT √ 2 + SHIFT √ 5 EXE	3.65028153987
$(-3)^2 = (-3)\times(-3) = 9$	((−) 3) x^2 EXE	9
$-3^2 = -(3\times 3) = -9$	(−) 3 x^2 EXE	−9
$2^2+3^2+4^2+5^2 = 54$	2 x^2 + 3 x^2 + 4 x^2 + 5 x^2 EXE	54
$\frac{1}{\frac{1}{3}-\frac{1}{4}} = 12$	(3 SHIFT x^{-1} − 4 SHIFT x^{-1}) SHIFT x^{-1} EXE	12
$8!(=1\times 2\times 3\times \ldots\ldots \times 8) = 40320$	8 SHIFT MATH F2(PRB) F1($x!$) EXE	40320
$\sqrt[3]{-27} = -3$	SHIFT $\sqrt[3]{}$ − 27 EXE	−3
$\frac{1}{2!}+\frac{1}{4!}+\frac{1}{6!}+\frac{1}{8!} = 0.543080357143$	2 SHIFT MATH F2(PRB) F1($x!$) SHIFT x^{-1} + 4 F1($x!$) SHIFT x^{-1} + 6 F1($x!$) SHIFT x^{-1} + 8 F1($x!$) SHIFT x^{-1} EXE	0.543080357143
What is the absolute value of the common logarithm of $\frac{3}{4}$? $\lvert \log\frac{3}{4} \rvert = 0.124938736608$	SHIFT MATH F3(NUM) F1(Abs) log (3 ÷ 4) EXE	0.124938736608
What is the integer part of −3.5?	SHIFT MATH F3(NUM) F2(Int) (−) 3.5 EXE	−3
What is the decimal part of −3.5?	SHIFT MATH F3(NUM) F3(Frac) (−) 3.5 EXE	−0.5
What is the nearest integer not exceeding −3.5?	SHIFT MATH F3(NUM) F5(Intg) (−) 3.5 EXE	−4

2-7 Coordinate Conversion

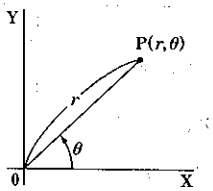
•Rectangular Coordinates



Pol

Rec

•Polar Coordinates



•Calculation results are stored in value memories I and J.

	I	J
Pol	r	θ
Rec	x	y

•With polar coordinates, θ can be calculated within a range of $-180° < \theta \leqq 180°$ (radians and grads have same range).
•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
To calculate r and $\theta°$ when $x=14$ and $y=20.7$.	SHIFT DRG F1(Deg) EXE	
	SHIFT MATH F5(CORD) F1(Pol( )	
	14 SHIFT , 20.7) EXE	24.9897979184 (r)
	(Continuing) ALPHA J EXE	
	SHIFT MATH F4(DMS) F2($\overset{\circ}{\ }\ '\ ''$)	55°55'42.2'' (θ)
To calculate x and y when $r=4.5$ and $\theta=\frac{2}{3}\pi$ rad.	SHIFT DRG F2(Rad) EXE	
	SHIFT MATH F5(CORD) F2(Rec( )	
	4.5 SHIFT , (2 ÷ 3 ×	
	SHIFT π)) EXE	−2.25 (x)
	(Continuing) ALPHA J EXE	3.89711431703 (y)

2-8 Permutation and Combination

•Permutation

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

•Combination

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

•The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
To calculate the possible number of different arrangements using 4 items selected from among of 10 items. ${}_{10}P_4=5040$	10 SHIFT MATH F2(PRB) F2($_nP_r$) 4 EXE	5040
To calculate the possible number of different combinations of 4 items that can be selected from among 10 items. ${}_{10}C_4=210$	10 SHIFT MATH F2(PRB) F3($_nC_r$) 4 EXE	210

2-9 Fractions

- Fractional values are displayed with the integer first, followed by the numerator and then the denominator.
- The following calculations cannot be performed in the BASE Mode.

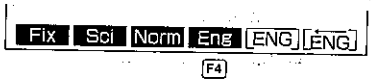
Example	Operation	Display
$\frac{2}{5}+3\frac{1}{4}=3\frac{13}{20}$	2 a⅞ 5 + 3 a⅞ 1 a⅞ 4 EXE	3⌟13⌟20
$=3.65$	(Conversion to decimal) a⅞	3.65
• Fractions can be converted to decimal values and vice versa.		
$3\frac{456}{78}=8\frac{11}{13}$ (Reduced)	3 a⅞ 456 a⅞ 78 EXE	8⌟11⌟13
	(Continuing) SHIFT d/c	115⌟13
• Fractions and improper fractions that can be reduced become reduced fractions when you press a calculation command key. Press SHIFT d/c to convert the value to an improper fraction.		
$\frac{1}{25789}+\frac{1}{45723}$		
$=6.06470532933\times10^{-5}$	1 a⅞ 25789 + 1 a⅞ 45723 EXE	6.06470532933E-05 (Norm 1 display format)
• When the total number of characters, including integer, numerator, denominator and delimiter marks exceeds 12, the input fraction is automatically displayed in decimal format.		
$\frac{1}{2}\times0.5=0.25$	1 a⅞ 2 × . 5 EXE	0.25
• Calculations containing both fractions and decimals are calculated in decimal format.		
$\frac{1}{\frac{1}{3}+\frac{1}{4}}=1\frac{5}{7}$	1 a⅞ (1 a⅞ 3 + 1 a⅞ 4) EXE	1⌟5⌟7
• You can include fractions within the numerator or denominator of a fraction by putting the numerator or denominator in parentheses.		

2-10 Engineering Symbol Calculations

Input engineering symbols using the Engineering Symbol Menu from the MATH Menu, as described on page 36.

Perform the following operation to change a displayed value to a corresponding Engineering Mode.

SHIFT DISP



F4 (Eng) EXE

Each time you perform this operation, the display changes between Engineering Mode and standard (non-engineering) format.

- The unit automatically selects the engineering symbol that makes the numeric value fall within the range of 1 to 999.
- The following calculations cannot be performed in the BASE Mode.

Example	Operation	Display
	SHIFT DISP F4 (Eng) EXE	
999k (kilo) + 25k (kilo) = 1.024M (mega)	999 SHIFT MATH F6 (ESYM) F6 (▽) F1 (k) + 25 F1 (k) EXE	1.024M
	SHIFT DISP F4 (Eng) EXE	1024000
	SHIFT DISP F4 (Eng) EXE	
$9\div10=0.9=900$m (milli)	9 ÷ 10 EXE	900.m
(Converts the displayed value to the next higher engineering unit, by shifting the decimal point three places to the right.)		
	F6 (ENG)	0.9
	F6 (ENG)	0.0009k
(Converts the displayed value to the next lower engineering unit, by shifting the decimal point three places to the left.)		
	F5 (ENG)	0.9
	F5 (ENG)	900.m
	F5 (ENG)	900000.μ
	F6 (ENG)	900.m
• The function menu item (ENG) appears above function key F6 only when the result of an operation is on the display.		

2-11 Number of Decimal Places, Number of Significant Digits, Display Format

- See page 25 for details on specifying the number of decimal places.
- See page 26 for details on specifying the number of significant digits.
- See page 26 for details on specifying the display format.

Example	Operation	Display
$100 \div 6 = 16.6666666666\ldots$	100 ÷ 6 EXE	16.6666666667
	(4 decimal places) SHIFT DISP F1 (Fix) 4 EXE	16.6667
	(Cancels specification) F3 (Norm) EXE	16.6666666667
	(5 significant digits) F2 (Sci) 5 EXE	1.6667E+01
	(Cancels specification) F3 (Norm) EXE	16.6666666667
	•Displayed values are rounded off to the place you specify.	
$200 \div 7 \times 14 = 400$	200 ÷ 7 × 14 EXE	400
	(3 decimal places) SHIFT DISP F1 (Fix) 3 EXE	400.000
	(Calculation continues using display capacity of 12 digits)	
	200 ÷ 7 EXE	28.571
	×	Ans × _
	14 EXE	400.000
	If the same calculation is performed using the specified number of digits:	
	200 ÷ 7 EXE	28.571
	(The value stored internally is cut off to the number of decimal places you specify.)	
	SHIFT MATH F3 (NUM) F4 (Rnd) EXE	28.571
	×	Ans × _
	14 EXE	399.994
	(Cancels specification) SHIFT DISP F3 (Norm) EXE	399.994

2-12 Calculations Using Memory

- See page 37 for details on value memories.

Example	Operation	Display
	193.2 → ALPHA A EXE	193.2
$\underline{193.2} \div 23 = 8.4$	ALPHA A ÷ 23 EXE	8.4
$\underline{193.2} \div 28 = 6.9$	ALPHA A ÷ 28 EXE	6.9
$\underline{193.2} \div 42 = 4.6$	ALPHA A ÷ 42 EXE	4.6
$\frac{9 \times 6 + 3}{(7-2) \times 8} = 1.425$	9 × 6 + 3 → ALPHA B EXE	57
	(7 − 2) × 8 → ALPHA C EXE	40
	ALPHA B ÷ ALPHA C EXE	1.425
	•The same result can be produced by entering (9 × 6 + 3) ÷ ((7 − 2) × 8) EXE.	
$23 + 9 = 32$	23 + 9 → ALPHA B EXE	32
$53 - 6 = 47$	53 − 6 EXE	47
$-) 45 \times 2 = 90$	ALPHA B + SHIFT Ans → ALPHA B EXE	79
$99 \div 3 = 33$	45 × 2 EXE	90
Total 22	ALPHA B − SHIFT Ans → ALPHA B EXE	−11
	99 ÷ 3 EXE	33
	ALPHA B + SHIFT Ans → ALPHA B EXE	22
$12 \times (\underline{2.3} + \underline{3.4}) - 5 = 63.4$	2.3 + 3.4 → ALPHA G EXE	5.7
$30 \times (\underline{2.3} + \underline{3.4} + \underline{4.5}) = 15$	12 × ALPHA G − 5 EXE	63.4
$\times \underline{4.5} = 238.5$	4.5 → ALPHA H EXE	4.5
	30 × (ALPHA G + ALPHA H) − 15 ALPHA H EXE	238.5
	•Multiplication signs (×) immediately before memory names can be omitted.	

2-13 BASE Mode Calculations

■Conversions

Example	Operation	Display
	MENU(BASE)EXE	
To convert $2A_{16}$ and 274_8 to decimal	AC F1(Dec)EXE	0
	F5(d~o)F2(h)2AEXE	42
	F4(o)274EXE	188
To convert 123_{10} and 1010_2 to hexadecimal	AC EXIT F2(Hex)EXE	00000000
	F5(d~o)F1(d)123EXE	0000007B
	F3(b)1010EXE	0000000A

■Negative Values

Example	Operation	Display
	MENU(BASE)EXE	
Negative of 110010_2	AC F3(Bin)EXE	0000000000000000
	F6(LOG)F1(Neg) 110010EXE	1111111111001110

■Arithmetic Operations

Example	Operation	Display
	MENU(BASE)EXE	
	AC F2(Hex)EXE	00000000
$123_8 \times ABC_{16} = 37AF4_{16}$	F5(d~o)F4(o)123× ABCEXE	00037AF4
$= 228084_{10}$	EXIT F1(Dec)EXE	228084
$7654_8 \div 12_{10} = 334.3333333_{10}$	AC F1(Dec)EXE	0
$= 516_8$	F5(d~o)F4(o)7654÷ 12EXE	334
	EXIT F4(Oct)EXE	00000000516

•Fractional parts are cut off before results are displayed.

■Logical Operations

•See page 50 for details on the logical operations menu.

Example	Operation	Display
	MENU(BASE)EXE	
	AC F2(Hex)EXE	00000000
19_{16} AND $1A_{16} = 18_{16}$	19F6(LOG)F3(and)1AEXE	00000018
	AC EXIT F3(Bin)EXE	0000000000000000
1110_2 AND $36_8 = 1110_2$	1110F6(LOG)F3(and)EXIT	
	F5(d~o)F4(o)36EXE	0000000000001110
	AC EXIT F4(Oct)EXE	00000000000
23_8 OR $61_8 = 63_8$	23F6(LOG)F4(or)61EXE	00000000063
	AC EXIT F2(Hex)EXE	00000000
120_{16} OR $1101_2 = 12D_{16}$	120F6(LOG)F4(or)EXIT	
	F5(d~o)F3(b)1101EXE	0000012D
	AC EXIT F3(Bin)EXE	0000000000000000
1010_2 AND (A_{16} OR 7_{16}) = 1010_2	1010F6(LOG)F3(and) (EXIT F5(d~o)F2(h)AEXIT	
	F6(LOG)F4(or)EXIT F5(d~o) F2(h)7)EXE	0000000000001010
	AC EXIT F2(Hex)EXE	00000000
5_{16} XOR $3_{16} = 6_{16}$	5F6(LOG)F5(xor)3EXE	00000006
	AC EXIT F2(Hex)EXE	00000000
$2A_{16}$ XNOR $5D_{16}$ = $FFFFFF88_{16}$	2AF6(LOG)F6(xnor)5DEXE	FFFFFF88
	AC EXIT F4(Oct)EXE	00000000000
Negation of 1234_8	F6(LOG)F2(Not)1234EXE	37777776543
	AC EXIT F2(Hex)EXE	00000000
Negation of $2FFFED_{16}$	F6(LOG)F2(Not) 2FFFEDEXE	FFD00012

Chapter 3

Differential, Integration, and Σ Calculations

Chapter 3 Differential, Integration, and Σ Calculations

3-1 How the Unit Calculates Differentials

The following is the input format for differentials:

[SHIFT] [d/dx] $f(x)$ [SHIFT] [,] a [SHIFT] [,] Δx [)]

- Δx: Increase/decrease of x
- a: Point for which you want to determine the derivative

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

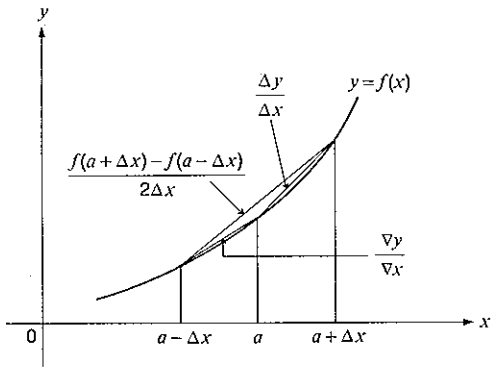
The differentiation for this type of calculation is defined as:

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

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

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

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



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

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

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

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

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

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

■To Perform a Differential Calculation

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

Input the function $f(x)$.

[AC] [SHIFT] [d/dx] [X,θ,T] [^] [3] [+] [4] [X,θ,T] [x²] [+] [X,θ,T] [−] [6] [SHIFT] [,]

```
d/dx(X^3+4X²+X−6,_
```

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

[3] [SHIFT] [,]

```
d/dx(X^3+4X²+X−6,3,_
```

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

[1] [EXP] [(−)] [5] [)]

```
d/dx(X^3+4X²+X−6,3,1E
−5)_
```

[EXE]

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

- X is the only expression that can be used in the function $f(x)$. If you use any other variable name (A through Z, r, or θ), that variable name is regarded as a constant, using the current contents of the corresponding value memory in the calculation.
- Input of Δx for the increase/decrease of x can be skipped. When you do, the unit automatically uses a value for Δx that is appropriate for the value of $x=a$, which you specified as the point for which you wanted to determine the derivative.
- In general, calculation precision is ±1 at the least significant digit of the result.

■Applications of Differential Calculations

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

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

Therefore:

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

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

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

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

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

•Note that you cannot use differential, integration, or Σ calculations inside of a differential calculation term.

Important

•Pressing AC during calculation of a differential (while the cursor is not shown on the display) interrupts the calculation.
•Always perform trigonometric integrations using radians (Rad Mode) as the unit of angular measurement (page 25).
•Differential calculations use value memories F through H for storage, deleting any contents that were previously stored. This also means that you cannot use these value memories during differential calculations.

Value Memory	F	G	H
Data Stored	a	Δx	$df(a)/dx$

In addition to the above, the value for derivative a is stored in value memory X.

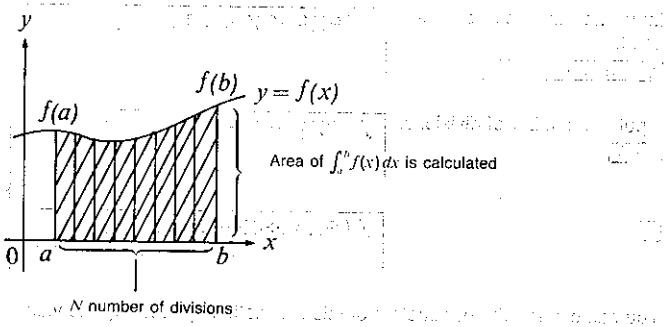
3-2 How the Unit Calculates Integrations

The following is the input format for integrations:

SHIFT ∫dx $f(x)$ SHIFT , a SHIFT , b SHIFT , n)

- n: Number of Divisions (value for n in $N=2^n$, n is an integer from 1 through 9)
- b: End Point
- a: Start Point

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



Integration calculations are performed by applying Simpson's Rule for the $f(x)$ function you input. This method requires that the number divisions be defined as $N=2^n$, where the value of n is an integer in the range of 1 through 9. If you do not specify a value for n, the calculator automatically assigns a value in accordance with the integration being performed.
As shown in the illustration above, integration calculations are performed by calculating integral values from a through b for the function $y=f(x)$ where $a\leqq x\leqq b$, and $f(x)\geqq 0$*. This in effect calculates the surface area of the shaded area in the illustration.
*If $f(x)<0$ where $a\leqq x\leqq b$, the surface area calculation produces negative values (surface area × −1).

Also note that the calculator uses the following value memories to store data during integration calculations.

Value Memory	K	L	M	N
Data Stored	a	b	$N=2^n$	$\int_a^b f(x)dx$

■To Perform an Integration Calculation

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

Input the function $f(x)$.
AC SHIFT $\int dx$ 2 X,θ,T x^2 + 3
X,θ,T + 4 SHIFT)

```
∫(2X²+3X+4,_
```

Input the start point and end point.
1 SHIFT , 5 SHIFT ,

```
∫(2X²+3X+4,1,5,_
```

Input the number of divisions.
6)

```
∫(2X²+3X+4,1,5,6)_
```

EXE

```
∫(2X²+3X+4,1,5,6)
                134.666666667
```

The result takes a few seconds to appear on the display.

You can confirm the parameters of this calculation by recalling the values stored in the value memories.

ALPHA K EXE

```
K
                -1
```
a

ALPHA L EXE

```
L
                 5
```
b

ALPHA M EXE

```
M
                64
```
N

ALPHA N EXE

```
N
        134.666666667
```

- X is the only expression that can be used in the function $f(x)$. If you use any other variable name (A through Z, r, or θ), that variable name is regarded as a constant, using the current contents of the corresponding value memory in the calculation.
- n and parentheses may be omitted. If you omit n, the calculator automatically selects the most appropriate value.
- In general, calculation precision is ±1 at the least significant digit of the result.

■Application of Integration Calculation

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

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

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

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

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

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

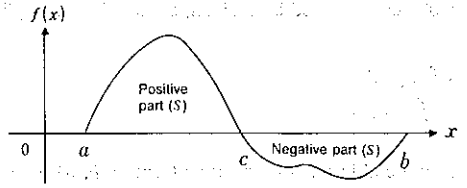
- Note that you cannot use differential, integration, or Σ calculations inside of an integration calculation term.

Important

- Pressing AC during calculation of an integral (while the cursor is not shown on the display) interrupts the calculation.
- Always perform trigonometric integrations using radians (Rad Mode) as the unit of angular measurement (see page 25).
- Integration calculations use value memories K through N for storage, deleting any contents that may be already stored. This also means that you cannot use these value memories during integration calculations.
  In addition to the above, the value that represents division beginning point a is stored in value memory X following completion of the integration calculation.
- This unit utilizes Simpson's rule for integration calculation. As the number of significant digits is increased, more calculation time is required. In some cases, calculation results may be erroneous even after considerable time is spent performing a calculation. In particular, when significant digits are less than 1, an ERROR (Ma ERROR) sometimes occurs.
- Integration involving certain types of functions or ranges can result in relatively large errors being generated in the values produced.

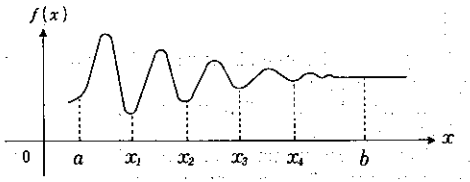
•Note the following points to ensure correct integration values.

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



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

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



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

3-3 Σ Calculations

To perform Σ calculations, select [F5] (Σ( ) from the Probability/Σ Function (PRB) Menu (page 35) and input the following Σ calculation formula.

[F5](Σ( )a_k[SHIFT][,]k[SHIFT][,]α[SHIFT][,]β[)]

- β — Last term of sequence $\{a_k\}$
- α — Initial term of sequence $\{a_k\}$
- k — Variable used by sequence $\{a_k\}$

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

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

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

■Example Σ Calculation

Example **To calculate the following:**

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

[AC][SHIFT][MATH][F2](PRB)
[F5](Σ( )[ALPHA][K][x^2][−][3][ALPHA][K]
[+][5][SHIFT][,]

(Input sequence $\{a_k\}$)

```
Σ(K²−3K+5, _
```

[ALPHA][K][SHIFT][,]

(Input variable used by sequence $\{a_k\}$)

```
Σ(K²−3K+5, K, _
```

[2][SHIFT][,][6][)]

(Input the initial term of sequence $\{a_k\}$ and last term of sequence $\{a_k\}$.)

```
Σ(K²−3K+5, K, 2, 6)_
```

[EXE]

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

•You can use only once variable in the function for input sequence $\{a_k\}$.
•Input integers only for the initial term of sequence $\{a_k\}$ and last term of sequence $\{a_k\}$.
•Closing parentheses may be omitted.

■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 **(sink, k, 1, 5), etc.**

•Note that you cannot use differential, integration, or Σ calculations inside of a Σ calculation term.

■Σ Calculation Precautions

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

Chapter 4

Complex Numbers

Chapter 4 Complex Numbers

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

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

4-1 Before Beginning a Complex Number Calculation

Before beginning a complex number calculation, press [SHIFT] [CMPLX] to display the complex number calculation menu.

[SHIFT] [CMPLX]

i	Abs	Arg	Conj	ReP	ImP
[F1]	[F2]	[F3]	[F4]	[F5]	[F6]

[F1](*i*) ..... Input of imaginary unit *i*
[F2](Abs) ..... Calculation of absolute value
[F3](Arg) ..... Calculation of argument
[F4](Conj) ..... Calculation of conjugate
[F5](ReP) ..... Extraction of real number part
[F6](ImP) ..... Extraction of imaginary number part

4-2 Performing Complex Number Calculations

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

■Arithmetic Operations

Arithmetic operations are the same as those you use for manual calculations (page 58). You can even use parentheses and memory.

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

[AC] [SHIFT] [CMPLX]
[(] [1] [+] [2] [F1](*i*) [)]
[+] [(] [2] [+] [3] [F1](*i*) [)]
[EXE]

```
(1+2i)+(2+3i)
                3+5i
i Abs Arg Conj ReP ImP
F1
```


Example 2 $(2+i)\times(2-i)=$

[AC] [SHIFT] [CMPLX]
[(] [2] [+] [F1](*i*) [)]
[×] [(] [2] [−] [F1](*i*) [)]
[EXE]

```
(2+i)×(2-i)
                  5
i Abs Arg Conj ReP ImP
F1
```

■Reciprocals, Square roots, and Squares

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

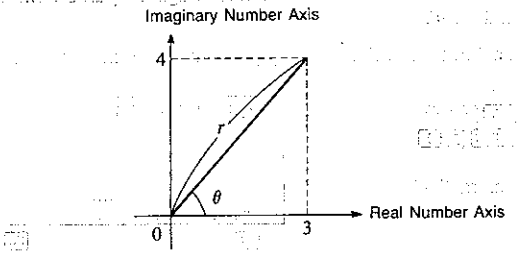
[AC] [SHIFT] [CMPLX]
[SHIFT] [√] [(] [3] [+] [F1](*i*) [)]
[EXE]

```
√(3+i)
     1.75531730182
    +0.284848784593i
i Abs Arg Conj ReP ImP
F1
```

■Absolute Value and Argument

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

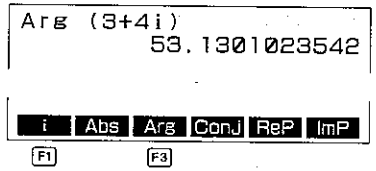
Example **To calculate absolute value (r) and argument (θ) for the complex number $3+4i$, with the unit of angular measurement set for degrees.**



[AC] [SHIFT] [CMPLX] [F2](Abs)
[(] [3] [+] [4] [F1](*i*) [)]
[EXE]
(Calculation of absolute value)

```
Abs (3+4i)
                  5
i Abs Arg Conj ReP ImP
F1 F2
```

AC SHIFT CMPLX F3 (Arg)
(3 + 4 F1 (i))
EXE
(Calculation of argument)



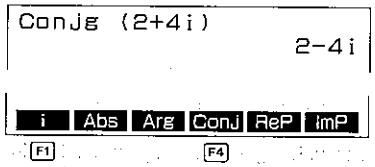
- The result of the argument calculation differs in accordance with the current unit of angular measurement setting (degrees, radians, grads).

■Conjugate Complex Numbers

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

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

AC SHIFT CMPLX F4 (Conj)
(2 + 4 F1 (i))
EXE

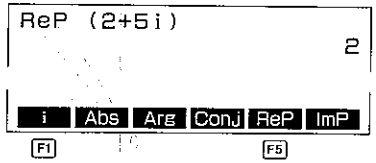


■Extraction of Real and Imaginary Number Parts

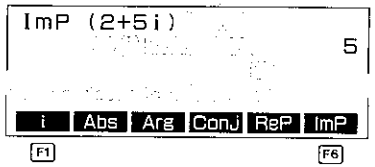
Use the following procedure to extract real part a and imaginary part b from a complex number with the format $a + bi$.

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

AC SHIFT CMPLX F5 (ReP)
(2 + 5 F1 (i))
EXE
(Real part extraction)



AC SHIFT CMPLX F6 (ImP)
(2 + 5 F1 (i))
EXE
(Imaginary part extraction)



4-3 Complex Number Calculation Precautions

- When the real number part or imaginary number part of a complex number has more than 21 digits, the two parts are displayed on separate lines.
- When either the real number part or imaginary number part equals zero, that part is not displayed.
- 20 bytes of memory are used whenever you assign a complex number to a value memory (page 37).
- The following functions can be used with complex numbers.

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

Int, Frac, Rnd, Intg, Fix, Sci, ENG, $\overleftarrow{\text{ENG}}$, ° ' '', $\overleftarrow{\text{° ' ''}}$, $a\,b/c$, d/c

Chapter 5

Statistical Calculations

Chapter 5 Statistical Calculations

There are two types of statistical calculations: *single-variable statistical calculations* performed using standard deviation, and *paired-variable statistical calculations* performed using regression.
Regression calculations can be performed using linear regression, logarithmic regression, exponential regression and power regression.
No matter what type of statistical calculations you decide to perform, you can tell the unit to either store the statistical data or not to store the data. Choosing storage of data causes the data you input to be stored in special statistical data memory. Choosing non-storage of data causes the data you input to be processed and discarded as soon as you input it. If you choose to store the data, be sure to clear memory contents before beginning calculations.

5-1 Single-Variable Statistical Calculations

You should use the Standard Deviation Mode to perform single-variable statistical calculations. In this mode, you can calculate the population standard deviation, the sample standard deviation, the mean, the sum of squares of the data, the sum of the data, and the number of data items.

■To Enter the Standard Deviation Mode without Data Storage

Highlight the **SD** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the Standard Deviation (SD) Mode.

[EXE]

The first line of the SD Mode Set Up Display should show "S-data : NON-STO". If it shows "S-data : STO" you have to change the set up using the procedure described on page 22.

```
  RUN   /SD
S-data  :NON-STO
S-graph :NON-DRAW
G-type  :RECT  /CONNECT
angle   :Deg
display :Norml
M-D/Cpy :M-Disp
[DT][CL]  ;  DEV  Σ  PQR
 F1   F2   F3   F4   F5   F6
```

•When drawing a graph for single-variable statistical data, STAT GRAPH must be set to the DRAW Mode (page 22).

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1](DT) ..... Inputs data
[F2](CL) ..... Clears data

[F3](;) ..... Used to input the number of data items
[F4](DEV) ..... Statistical/representative menu
[F5](Σ) ..... Sum data menu
[F6](PQR) ..... Probability distribution menu

The unit uses the following value memories to store values. Do not use these memories for storage if you plan to perform statistical operations.

Value Memory	U	V	W
Statistical Data	Σx^2	Σx	n

• To input data

Example 1 **To input the data 10, 20, 30**

[SHIFT][CLR][F2](Scl)[EXE][EXIT]

10[F1](DT)20[F1](DT)30[F1](DT)

Example 2 **To input the data 10, 20, 20, 30**

10[F1](DT)20[F1](DT)[F1](DT)30[F1](DT)

Note that simply pressing [F1](DT) inputs the previously entered data.

Example 3 **To input the data 10, 20, 20, 20, 20, 20, 20, 30**

10[F1](DT)20[F3](;)6[F1](DT)30[F1](DT)

Note that you can input multiple data items by entering the data, pressing [F3](;), and then entering the number of data items.

• To delete data

Example 1 **Data input sequence: 40[F1](DT)20[F1](DT)30[F1](DT)50[F1](DT)**

To delete the 50[F1](DT) (last data item entered), press [F2](CL).

Example 2 **Data input sequence: 40[F1](DT)20[F1](DT)30[F1](DT)50[F1](DT)**

To delete the 20[F1](DT), enter 20[F2](CL).

Example 3 **Data input sequence: 30[F1](DT)50[F1](DT)120[F3](;)**

To delete the 120[F3](;), press [AC].

Example 4 **Data input sequence: 30[F1](DT)50[F1](DT)120[F3](;)31**

To delete the 120[F3](;)31, press [AC].

Example 5 **Data input sequence: 30[F1](DT)50[F1](DT)120[F3](;)31[F1](DT)**

To delete the 120[F3](;)31[F1](DT) (last item entered), press [F2](CL).

Example 6 **Data input sequence: 50[F1](DT)120[F3](;)31[F1](DT)30[F1](DT)**

To delete the 120[F3](;)31[F1](DT), enter 120[F3](;)31[F2](CL).

■To Enter the Standard Deviation Mode with Data Storage

MENU(SD)EXE

The first line of the SD Mode Set Up Display should show "S-data : STO". If it shows "S-data : NON-STO" you have to change the set up using the procedure described on page 22.

```
  RUN   /SD
S-data  :STO
S-graph :NON-DRAW
G-type  :RECT  /CONNECT
angle   :Deg
display :Norml
M-D/Cpy :M-Disp
[DT] [EDIT] [ : ] [DEV] [Σ] [PQR]
 F1   F2    F3   F4    F5   F6
```

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

- F1(DT) ..... Inputs data
- F2(EDIT) ..... Edit function menu
- F3(;) ..... Used to input the number of data items
- F4(DEV) ..... Statistical/representative menu
- F5(Σ) ..... Sum data menu
- F6(PQR) ..... Probability distribution menu

- Σx^2, Σx, and n data are stored in their own memory area, and so they do not use value memories.
- See pages 103 and 162 for the formulas used to calculate standard deviation, mean, and probability distribution.
- The maximum value is the largest value input for X, while the minimum value is the smallest value input for X.
- The median is the middle value of the distribution. If any data item has a negative value, or if it is greater than 10^{10}, or if the data includes a data item of 0, an "Ma ERROR" occurs.

• To input data

Example 1 **To input the data 10, 20, 30**

Before actually beginning data input, use the following sequence to delete any data that may already be stored inside the special statistical data memory.

F2(EDIT)

```
[DEL] [INS] [ERS]
 F1    F2    F3
```

F3(ERS)

```
[YES] ERASE ALL DATA [NO]
 F1                   F6
```

F1(YES)

```
[DT] [EDIT] [ : ] [DEV] [Σ] [PQR]
 F1
```

10F1(DT)20F1(DT)30F1(DT)

Example 2 **To input the data 10, 20, 20, 30**
10F1(DT)20F1(DT)F1(DT)30F1(DT)

Note that simply pressing F1(DT) inputs the previously entered data.

Example 3 **To input the data 10, 20, 20, 20, 20, 20, 20, 30**
10F1(DT)20F3(;)6F1(DT)30F1(DT)

Note that you can input multiple data items by entering the data, pressing F3(;), and then entering the number of data items.

• To edit data items stored in memory

Example **To change 50 to 54**

From the function menu at the bottom of the SD Mode set up display, press F2(EDIT) to start the editing operation.

F2(EDIT)

▼▼

```
   X    f
1 [52   1
2  52   1
3  50   1
4  58   2
5  56   1]
                50
[DEL] [INS] [ERS]
```

5 4

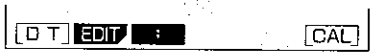
```
   X    f
1 [52   1
2  52   1
3  50   1
4  58   2
5  56   1]
54_
[DEL] [INS] [ERS]
```

EXE

```
   X    f
1 [52   1
2  52   1
3  54   1
4  58   2
5  56   1]
                 1
[DEL] [INS] [ERS]
```

After you finish editing the data, press [EXIT] and then [F6](CAL) (see page 103).

[EXIT]



[F6](CAL)

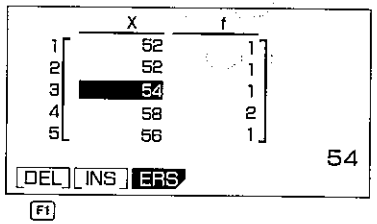
• To delete specific data items stored in memory

Example **To delete 54**

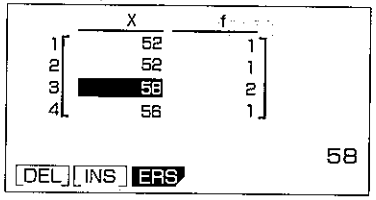
From the function menu at the bottom of the SD Mode set up display, press [F2](EDIT) to start the editing operation.

[F2](EDIT)

[▼][▼]



[F1](DEL)



After you finish deleting the data, press [EXIT] and then [F6](CAL) (see page 103).

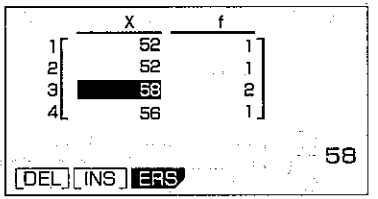
• To insert data items into data stored in memory

Example **To insert 0 between 52 and 58**

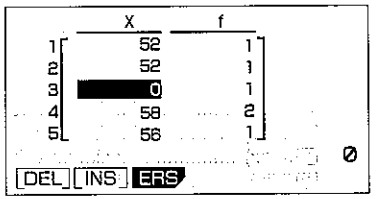
From the function menu at the bottom of the SD Mode set up display, press [F2](EDIT) to start the editing operation.

[F2](EDIT)

[▼][▼]



[F2](INS)



After you finish inserting the data, press [EXIT] and then [F6](CAL) (see page 103).

■Performing Single-Variable Calculations

After inputting the data, select the type of operation you want from the function menu at the bottom of the SD Mode set up display. Press one of the following function keys to display a menu of available operations.

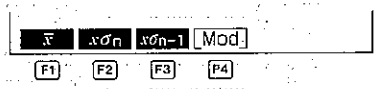
[F4](DEV) ..... Statistical/representative menu
[F5](Σ) ..... Sum data menu
[F6](PQR) ..... Probability distribution menu

Each of these menus is described in detail below.

Without data storage (S-data : NON-STO)

• Statistical/Representative Menu

[F4](DEV)



[F1]($\bar{x}$) ..... Mean of x-data
[F2]($x\sigma_n$) ..... Population standard deviation of x-data
[F3]($x\sigma_{n-1}$) ..... Sample standard deviation of x-data
[F4](Mod) ..... Mode value for input data

•The function menu selection (Mod) appears above function key [F4] only after you draw a single-variable statistic graph (bar graph) on the display (page 165).

With data storage (S-data : STO)

- **Statistical/Representative Menu**

[F4](DEV)

[F1]($\bar{x}$) ..... Mean of x-data
[F2]($x\sigma_n$) ..... Population standard deviation of x-data
[F3]($x\sigma_{n-1}$) ..... Sample standard deviation of x-data
[F4](▽) ..... Representative calculation menu

- **Representative Menu**

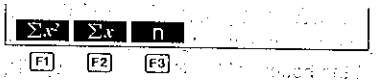
[F4](▽)

[F1](Mod) ..... Mode value for input data
[F2](Med) ..... Median value for input data
[F3](Max) ..... Maximum value for input data
[F4](Min) ..... Minimum value for input data

•The function menu selection (Mod) appears above function key [F1] only after you draw a single-variable statistic graph (bar graph) on the display (page 165).

- **Sum Data Menu**

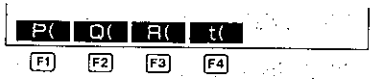
[F5](Σ)



[F1](Σx^2) ..... Sum of squares of x-data
[F2](Σx) ..... Sum of x-data
[F3](n) ..... Number of x-data items

- **Probability Distribution Menu**

[F6](PQR)



[F1](P ( ) ..... Probability P (t) value
[F2](Q ( ) ..... Probability Q (t) value
[F3](R ( ) ..... Probability R (t) value
[F4](t ( ) ..... Normalized variation t (x)

5-2 Paired-Variable Statistical Calculations

You should use the Regression Mode to perform paired-variable statistical calculations. In this mode, you can perform linear regression, logarithmic regression, exponential regression, and power regression.

■To Enter the Regression Mode without Data Storage

Highlight the **REG** icon on the Main Menu.

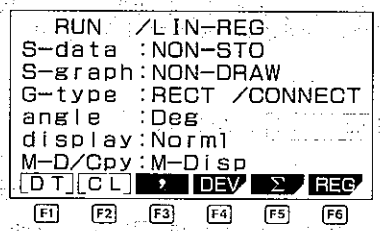
[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the Regression (REG) Mode.

[EXE]

The first line of the REG Mode Set Up Display should show "S-data : NON-STO". If it shows "S-data : STO" you have to change the set up using the procedure described on page 22.



•When drawing a graph for paired-variable statistical data, STAT GRAPH must be set to the DRAW Mode (page 22).

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

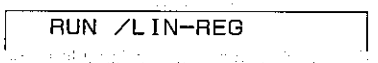
[F1](DT) ..... Inputs data
[F2](CL) ..... Clears data
[F3](,) ..... Inputs comma between x- and y-data
[F4](DEV) ..... Statistical menu
[F5](Σ) ..... Sum data menu
[F6](REG) ..... Regression/estimated value menu

The unit uses the following value memories to store values. Do not use these memories for storage if you plan to perform statistical operations.

Value Memory	P	Q	R	U	V	W
Statistical Data	Σy^2	Σy	Σxy	Σx^2	Σx	n

■To Enter the Linear Regression Mode

[SHIFT][SETUP][▼][▼][▼][▼]
[F1](LIN)[EXIT]



The linear regression formula is $y = A + Bx$.

• To input data for linear regression

Example 1 **To input the data 10/20, 20/30, 20/30, 40/50**

[SHIFT][CLR][F2](Scl)[EXE]
10[F3](,)20[F1](DT)
20[F3](,)30[F1](DT)
[F1](DT)
40[F3](,)50[F1](DT)

Example 2 **To input the data 10/20, 20/30, 20/30, 20/30, 20/30, 20/30, 40/50**

10[F3](,)20[F1](DT)
20[F3](,)30[ALPHA][:]5[F1](DT)
40[F3](,)50[F1](DT)

Note that you can input multiple data pairs by entering the data, pressing [ALPHA][:], and then entering the number of data pairs.

• To delete data

Example 1 **Data input sequence:** 10[F3](,)40[F1](DT)
20[F3](,)20[F1](DT)
30[F3](,)30[F1](DT)
40[F3](,)50[F1](DT)

To delete the 40[F3](,)50[F1](DT) (last data pair entered), press [F2](CL).

Example 2 **Data input sequence:** 10[F3](,)40[F1](DT)
20[F3](,)20[F1](DT)
30[F3](,)30[F1](DT)
40[F3](,)50

To delete the 40[F3](,)50, press [AC].

Example 3 **Data input sequence:** 10[F3](,)40[F1](DT)
20[F3](,)20[F1](DT)
30[F3](,)30[F1](DT)
40[F3](,)50[F1](DT)

To delete the 20[F3](,)20[F1](DT), enter 20[F3](,)20[F2](CL).

■To Enter the Logarithmic Regression Mode

[SHIFT][SETUP][▼][▼][▼][▼]
[F2](LOG)[EXIT]

```
RUN  /LOG-REG
```

The logarithmic regression formula is $y = A + B \cdot \ln x$.

• To input data for logarithmic regression

Input data using the same procedures as described for linear regression on page 98.

• To delete data

Delete data using the same procedures as described for linear regression on page 98.

The following shows the equivalent values between linear regression and logarithmic regression.

Linear Regression	Logarithmic Regression
Σx	$\Sigma \ln x$
Σx^2	$\Sigma (\ln x)^2$
Σxy	$\Sigma \ln x \cdot y$

■To Enter the Exponential Regression Mode

[SHIFT][SETUP][▼][▼][▼][▼]
[F3](EXP)[EXIT]

```
RUN  /EXP-REG
```

The exponential regression formula is $y = A \cdot e^{B \cdot x}$ ($\ln y = \ln A + Bx$).

• To input data for exponential regression

Input data using the same procedures as described for linear regression on page 98.

• To delete data

Delete data using the same procedures as described for linear regression on page 98.

The following shows the equivalent values between linear regression and exponential regression.

Linear Regression	Exponential Regression
Σy	$\Sigma \ln y$
Σy^2	$\Sigma (\ln y)^2$
Σxy	$\Sigma x \cdot \ln y$

■To Enter the Power Regression Mode

[SHIFT][SETUP][▼][▼][▼][▼]
[F4](PWR)[EXIT]

```
RUN  /PWR-REG
```

The power regression formula is $y = A \cdot x^B$ ($\ln y = \ln A + B \ln x$).

• To input data for power regression

Input data using the same procedures as described for linear regression on page 98.

• To delete data

Delete data using the same procedures as described for linear regression on page 98.

The following shows the equivalent values between linear regression and power regression.

Linear Regression	Power Regression
Σx	$\Sigma \ln x$
Σx^2	$\Sigma (\ln x)^2$
Σy	$\Sigma \ln y$
Σy^2	$\Sigma (\ln y)^2$
Σxy	$\Sigma \ln x \cdot \ln y$

■To Enter the Regression Mode with Data Storage

[MENU](REG)[EXE]

The first line of the REG Mode Set Up Display should show "S-data : STO". If it shows "S-data : NON-STO" you have to change the set up using the procedure described on page 22.

```
  RUN   /LIN-REG
S-data  :STO
S-graph :NON-DRAW
G-type  :RECT /CONNECT
angle   :Deg
display :Norml
M-D/Cpy :M-Disp
[DT][EDIT][ , ][DEV][Σ][REG]
 F1   F2   F3   F4   F5   F6
```


The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1](DT) ..... Inputs data
[F2](EDIT) ..... Displays an edit function menu
[F3](,) ..... Inputs comma between x- and y-data
[F4](DEV) ..... Statistical menu
[F5](Σ) ..... Sum data menu
[F6](REG) ..... Regression/estimated value menu

• Σx^2, Σx, n, Σy^2, Σy, and Σxy data are stored in their own memory area, and so they do not use value memories.

• To input data

The following input procedures can be used to input data for linear, logarithmic, exponential, and power regression.

Example 1 **To input the data 10/20, 20/30, 20/30, 40/50**

Before actually beginning data input, use the following sequence to delete any statistical data stored in memory.

[F2](EDIT)[F3](ERS)[F1](YES)
10[F3](,)20[F1](DT)
20[F3](,)30[F1](DT)
[F1](DT)
40[F3](,)50[F1](DT)

Example 2 **To input the data 10/20, 20/30, 20/30, 20/30, 20/30, 20/30, 40/50**

10[F3](,)20[F1](DT)
20[F3](,)30[ALPHA][:]5[F1](DT)
40[F3](,)50[F1](DT)

Note that you can input multiple data pairs by entering the data, pressing [ALPHA][:], and then entering the number of data pairs.

• To edit data

To change, delete, insert, or clear data, press [F2](EDIT) to display the edit function menu and then perform the same procedures as those described for single-variable data on pages 93 to 95.

■Performing Paired-Variable Calculations

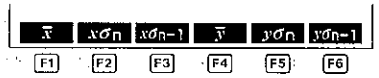
After inputting the data, select the type of operation you want from the function menu at the bottom of the REG Mode set up display. Press one of the following function keys to display a menu of available operations.

[F4](DEV) ..... Statistical menu
[F5](Σ) ..... Sum data menu
[F6](REG) ..... Regression/estimated value menu

Each of these menus is described in detail below.

• Statistical Menu

[F4](DEV)



[F1]($\bar{x}$) ..... Mean of x-data
[F2]($x\sigma_n$) ..... Population standard deviation of x-data
[F3]($x\sigma_{n-1}$) ..... Sample standard deviation of x-data
[F4]($\bar{y}$) ..... Mean of y-data
[F5]($y\sigma_n$) ..... Population standard deviation of y-data
[F6]($y\sigma_{n-1}$) ..... Sample standard deviation of y-data

• Sum Data Menu

[F5](Σ)

[F1](Σx^2) ..... Sum of squares of x-data
[F2](Σx) ..... Sum of x-data
[F3](n) ..... Number of items
[F4](Σy^2) ..... Sum of squares of y-data
[F5](Σy) ..... Sum of y-data
[F6](Σxy) ..... Sum of products of x-data and y-data

• Regression/Estimated Value Menu

[F6](REG)

[F1](A) ..... Constant term A
[F2](B) ..... Regression coefficient B
[F3](r) ..... Correlation coefficient r
[F4]($\hat{x}$) ..... Estimated value of x
[F5]($\hat{y}$) ..... Estimated value of y

5-3 Things to Remember during Statistical Calculations

Anytime you delete, insert, or otherwise edit statistical data, be sure to press [EXIT] and then [F6](CAL) to re-calculate the statistical results before inputting new data or performing any other calculation. You should also press [EXIT] followed by [F6](CAL) after you delete the statistical data memory using Scl ([SHIFT][CLR][F2](Scl)[EXE]).

5-4 Examples of Statistical Calculations

The following are the formulas used by the unit to calculate standard deviation and mean.

•Standard Deviation

$$\sigma_n = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n}} = \sqrt{\frac{\Sigma x^2-(\Sigma x)^2/n}{n}}$$

Using all data from a finite population to determine the standard deviation for the population

$$\sigma_{n-1} = \sqrt{\frac{\sum_{i=1}^{n}(x_i-\bar{x})^2}{n-1}} = \sqrt{\frac{\Sigma x^2-(\Sigma x)^2/n}{n-1}}$$

Using sample data from a population to determine the standard deviation for the population

•Mean

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{\Sigma x}{n}$$

Example	Operation	Display
Data 55, 54, 51, 55, 53, 53, 54, 52	[SHIFT][SETUP][▼][▼][F2](NON-)[EXIT]	
	[SHIFT][CLR][F2](Scl)[EXE][EXIT] (Clears memory)	
	55[F1](DT)**54**[F1](DT)	
	51[F1](DT)**55**[F1](DT)	
	53[F1](DT)[F1](DT)**54**[F1](DT)	
	52[F1](DT)	**52**
*You can press the function keys to obtain results in any sequence.		
	(Standard deviation σ_n) [F4](DEV)[F2]($x\sigma_n$)[EXE]	**1.31695671911**
	(Standard deviation σ_{n-1}) [F3]($x\sigma_{n-1}$)[EXE]	**1.40788595317**
	(Mean $\bar{x}$) [F1]($\bar{x}$)[EXE]	**53.375**
	(Number of data n) [EXIT][F5](Σ)[F3](n)[EXE]	**8**
	(Sum total Σx) [F2](Σx)[EXE]	**427**
	(Sum of squares Σx^2) [F1](Σx^2)[EXE]	**22805**

To calculate the deviation of the unbiased variance, the difference between each datum, and mean of the above data	(Continuing) EXIT F4(DEV)	
	F3($x\sigma_{n-1}$) x^2 EXE	1.98214285714
	55 − F1($\bar{x}$) EXE	1.625
	54 − F1($\bar{x}$) EXE	0.625
	51 − F1($\bar{x}$) EXE	−2.375
	⋮	⋮
Determine the following: P distribution Q distribution R distribution t distribution	EXIT F6(PQR)	
	F1(P( )0.2) EXE	0.57926
	F2(Q( )0.25) EXE	0.098706
	F3(R( )3) EXE	1.35E−03
	F4(t( )58) EXE	3.51188458428
To calculate x and σ_{n-1} for the following data	SHIFT SETUP ▼ ▼ F1(STO) EXIT	
	SHIFT CLR F2(Scl) EXE	
	(Clears memory)	
	110 F3(;)10 F1(DT)	110
	130 F3(;)31 F1(DT)	130
	150 F3(;)24 F1(DT)	150
	170 F1(DT) F1(DT)	170
		170
	190 F1(DT) F1(DT) F1(DT)	190
		190
		190
	F6(CAL) F5(Σ) F3(n) EXE	70
	EXIT F4(DEV) F1($\bar{x}$) EXE	137.714285714
	F3($x\sigma_{n-1}$) EXE	18.4289806878
To determine Med, Max and Min.	F4(▽) F2(Med) EXE	130
	F3(Max) EXE	190
	F4(Min) EXE	110

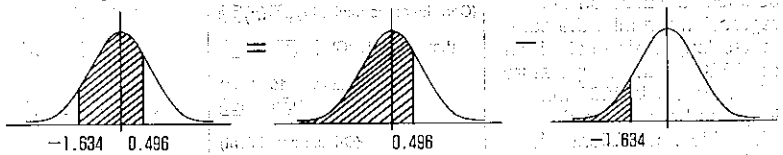
Class no.	Value	Frequency
1	110	10
2	130	31
3	150	24
4	170	2
5	190	3

Example	Operation	Display
The table below shows the heights 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 do the 175.5 cm tall students fall?	SHIFT SETUP ▼ ▼ F1(STO) EXIT	
	F2(EDIT) F3(ERS) F1(YES)	
	158.5 F1(DT)	158.5
	160.5 F1(DT)	160.5
	163.3 F3(;)2 F1(DT)	163.3
	167.5 F3(;)2 F1(DT)	167.5
	170.2 F3(;)3 F1(DT)	170.2
	173.3 F3(;)4 F1(DT)	173.3
	175.5 F3(;)2 F1(DT)	175.5
	178.6 F3(;)2 F1(DT)	178.6
	180.4 F3(;)2 F1(DT)	180.4
	186.7 F1(DT)	186.7
	F6(PQR)	
	(Normalized variate t for 160.5 cm) F4(t( )160.5) EXE	−1.63385594752 (≒ −1.634)
	(Normalized variate t for 175.5 cm) F4(t( )175.5) EXE	0.496334336077 (≒0.496)
	(Percentage of total) F1(P( )0.496) − F1(P( )(−)1.634) EXE	0.638921 (Result: 63.9% overall)
	(Percentile) F3(R( )0.496) EXE	0.30995 (Result: 31 percentile)

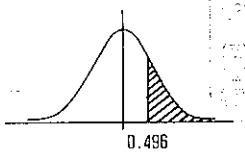
Class no.	Height (cm)	Frequency
1	158.5	1
2	160.5	1
3	163.3	2
4	167.5	2
5	170.2	3
6	173.3	4
7	175.5	2
8	178.6	2
9	180.4	2
10	186.7	1

*The following distribution curves illustrate the two concepts covered in this problem.

•Percentage of the Total



•Percentile



• Regression

The following are the formulas the unit uses to calculate constant term A and regression coefficient B for the regression formula $y = A + Bx$.

$$A = \frac{\Sigma y - B \cdot \Sigma x}{n} \qquad B = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{n \cdot \Sigma x^2 - (\Sigma x)^2}$$

The following is the formula the unit uses to calculate correlation coefficient r and estimated values of x and y.

$$r = \frac{n \cdot \Sigma xy - \Sigma x \cdot \Sigma y}{\sqrt{\{n \cdot \Sigma x^2 - (\Sigma x)^2\}\{n \cdot \Sigma y^2 - (\Sigma y)^2\}}}$$

$$\hat{y} = A + Bx \qquad \hat{x} = \frac{y - A}{B}$$

■Linear Regression

Example

•Relationship between temperature and the length of a steel bar

Temperature	Length
10°C	1003mm
15°C	1005mm
20°C	1010mm
25°C	1011mm
30°C	1014mm

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, the estimated length of the steel bar at 18°C and the temperature when the bar is 1000 mm long can be calculated. The critical coefficient (r^2) and covariance

$$\left(\frac{\Sigma xy - n \cdot \bar{x} \cdot \bar{y}}{n-1}\right)$$

can also be calculated.

Operation	Display
SHIFT SETUP ▼ ▼ F2(NON-) ▼ ▼ F1(LIN) EXIT	
SHIFT CLR F2(Scl) EXE EXIT (Clears memory)	
10 F3(,) 1003 F1(DT)	10
15 F3(,) 1005 F1(DT)	15
20 F3(,) 1010 F1(DT)	20
25 F3(,) 1011 F1(DT)	25
30 F3(,) 1014 F1(DT)	30
(Constant term A) F6(REG) F1(A) EXE	997.4
(Regression coefficient B) F2(B) EXE	0.56
(Correlation coefficient r) F3(r) EXE	0.982607368881
(Length at 18°C) 18 F5($\hat{y}$) EXE	1007.48
(Temperature at 1000mm) 1000 F4($\hat{x}$) EXE	4.64285714286
(Critical coefficient) F3(r) x^2 EXE	0.965517241379
(Covariance) (EXIT F5(Σ) F6(Σxy) − F3(n) × EXIT F4(DEV) F1($\bar{x}$) × F4($\bar{y}$)) ÷ (EXIT F5(Σ) F3(n) − 1) EXE	35

■Logarithmic Regression

•The logarithmic regression formula is $y = A + B \cdot \ln x$.
•Σx, Σx^2, and Σxy are obtained as $\Sigma \ln x$, $\Sigma (\ln x)^2$, and $\Sigma \ln x \cdot y$ respectively.

Example

xi	yi
29	1.6
50	23.5
74	38.0
103	46.4
118	48.9

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, estimated value $\hat{y}$ can be obtained for $xi = 80$, and estimated value $\hat{x}$ can be obtained for $yi = 73$.

Operation	Display
SHIFT SETUP ▼ ▼ F2(NON-) ▼ ▼ F2(LOG) EXIT	
SHIFT CLR F2(Scl) EXE EXIT (Clears memory)	
29 F3(,) 1.6 F1(DT)	3.36729582999
50 F3(,) 23.5 F1(DT)	3.91202300543
74 F3(,) 38.0 F1(DT)	4.3040650932
103 F3(,) 46.4 F1(DT)	4.63472898823
118 F3(,) 48.9 F1(DT)	4.77068462447
(Constant term A) F6(REG) F1(A) EXE	−111.128397647
(Regression coefficient B) F2(B) EXE	34.0201475016
(Correlation coefficient r) F3(r) EXE	0.994013946616
($\hat{y}$ when $xi = 80$) 80 F5($\hat{y}$) EXE	37.9487948202
($\hat{x}$ when $yi = 73$) 73 F4($\hat{x}$) EXE	224.154131261

■Exponential Regression

- The exponential regression formula is $y = A \cdot e^{B \cdot x}$ ($\ln y = \ln A + Bx$).
- Σy is obtained as $\Sigma \ln y$, Σy^2 as $\Sigma(\ln y)^2$, and Σxy as $\Sigma x \cdot \ln y$.

Example	Operation	Display
	[SHIFT][SETUP][▼][▼][F2](NON-) [▼][▼][F3](EXP)[EXIT]	
	[SHIFT][CLR][F2](Scl)[EXE][EXIT] (Clears memory)	
	6.9[F3](,)**21.4**[F1](DT)	**6.9**
	12.9[F3](,)**15.7**[F1](DT)	**12.9**
	19.8[F3](,)**12.1**[F1](DT)	**19.8**
	26.7[F3](,)**8.5**[F1](DT)	**26.7**
	35.1[F3](,)**5.2**[F1](DT)	**35.1**
	(Constant term A) [F6](REG)[F1](A)[EXE]	**30.4975874259**
	(Regression coefficient B) [F2](B)[EXE]	**−0.0492037083077**
	(Correlation coefficient r) [F3](r)[EXE]	**−0.997247351988**
	($\hat{y}$ when $xi = 16$) **16**[F5]($\hat{y}$)[EXE]	**13.8791573943**
	($\hat{x}$ when $yi = 20$) **20**[F4]($\hat{x}$)[EXE]	**8.57486804655**

xi	yi
6.9	21.4
12.9	15.7
19.8	12.1
26.7	8.5
35.1	5.2

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, estimated value $\hat{y}$ can be obtained for $xi = 16$, and estimated value $\hat{x}$ can be obtained for $yi = 20$.

■Power Regression

- The power regression formula is $y = A \cdot x^B$ ($\ln y = \ln A + B \ln x$).
- Σx is obtained as $\Sigma \ln x$, Σx^2 as $\Sigma(\ln x)^2$, Σy as $\Sigma \ln y$, Σy^2 as $\Sigma(\ln y)^2$, and Σxy as $\Sigma \ln x \cdot \ln y$.

Example	Operation	Display
	[SHIFT][SETUP][▼][▼][F2](NON-) [▼][▼][F4](PWR)[EXIT]	
	[SHIFT][CLR][F2](Scl)[EXE][EXIT] (Clears memory)	
	28[F3](,)**2410**[F1](DT)	**3.33220451018**
	30[F3](,)**3033**[F1](DT)	**3.40119738166**
	33[F3](,)**3895**[F1](DT)	**3.49650756147**
	35[F3](,)**4491**[F1](DT)	**3.55534806149**
	38[F3](,)**5717**[F1](DT)	**3.63758615973**
	(Constant term A) [F6](REG)[F1](A)[EXE]	**0.238801068543**
	(Regression coefficient B) [F2](B)[EXE]	**2.77186615763**
	(Correlation coefficient r) [F3](r)[EXE]	**0.998906255127**
	($\hat{y}$ when $xi = 40$) **40**[F5]($\hat{y}$)[EXE]	**6587.67458923**
	($\hat{x}$ when $yi = 1000$) **1000**[F4]($\hat{x}$)[EXE]	**20.2622568108**

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

The data in the above table can be used to obtain the terms of the regression formula and the correlation coefficient. Based on the regression formula, estimated value $\hat{y}$ can be obtained for $xi = 40$, and estimated value $\hat{x}$ can be obtained for $yi = 1000$.

A313043-2

Chapter 6

Using the Matrix Mode

A313043-2

Chapter 6 Using the Matrix Mode

This calculator provides you with 26 variable matrices (Mat A through Mat Z) and a special matrix answer memory (Mat Ans) that you can use to perform the following types of calculations. Note that the maximum matrix dimension (size) that can be used is 255 × 255.

- **Addition, subtraction, multiplication**
- **Scalar products**
- **Determinants**
- **Transposed matrices**
- **Inverted matrices**
- **Squaring**
- **Row element calculations (modification)**

6-1 Before Performing Matrix Calculations

Before beginning a matrix calculation you have to first enter the correct mode.

■To enter the Matrix Mode

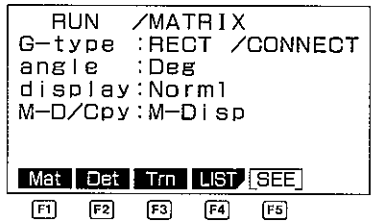
Highlight the **MAT** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the Matrix Mode.

[EXE]



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

- [F1](Mat) ..... For specification of matrix type
- [F2](Det) ..... Determinant
- [F3](Trn) ..... Transposition
- [F4](LIST) ..... Display of matrix list
- [F5](SEE) ..... Display of the latest matrix calculation result

About the Matrix Answer Memory (Mat Ans)

Much like the standard Answer Memory (page 31), the Matrix Answer Memory automatically stores the latest matrix calculation result. Note the following points whenever you are using the Matrix Answer Memory.

- Whenever you perform a matrix calculation, the values that make up the result are stored using the applicable matrix dimension. Anything previously stored in Matrix Answer Memory is replaced by the new data.
- Matrix Answer Memory contents are not affected by a matrix substitution operation (page 127).

■Matrix List

Use the matrix list to specify the size of the matrix you want to use.

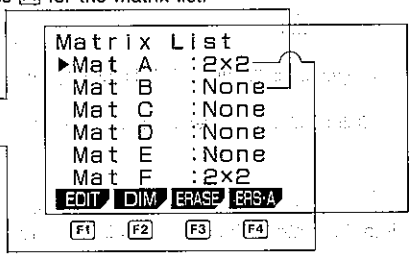
• To display the matrix list

While the Matrix Mode is displayed, press [F4] for the matrix list.

[F4](LIST)

No dimension preset

2 (row) × 2 (column) matrix



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

- [F1](EDIT) ..... Recall of a matrix for editing
- [F2](DIM) ..... Setting of matrix dimensions
- [F3](ERASE) ..... Deletion of selected matrix
- [F4](ERS·A) ..... Deletion of all matrices

■Matrix Input

You can use either of the two following methods for matrix input.

- Inputting component data, and then using [→] to directly assign the data to a matrix (automatic dimensioning).
- Specifying the dimensions (size) of the matrix and then inputting data for each component.

• To directly assign data to a matrix

Example To input the following 2 × 3 matrix as Matrix A.

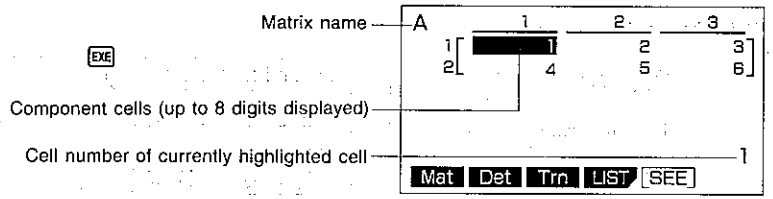
$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \end{pmatrix}$$

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

```
[[1,2,3][4,5,6]]→Mat
A_
```

```
Mat Det Trn LIST SEE
```
[F1]

[EXE]



- The following shows the data input format and the sequence used to store input data into the matrix. The subscripts indicate row (r) and column (c) locations.

Input Format

$[[a_{11}, a_{12}, \ldots, a_{1c}]\ [a_{21}, a_{22}, \ldots, a_{2c}]\ \ldots\ [a_{r1}, a_{r2}, \ldots, a_{rc}]]$ [⊟] [F1] (Mat) (matrix name A through Z)

Data Input

$$\begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1c} \\ a_{21} & a_{22} & \cdots & a_{2c} \\ \vdots & \vdots & & \vdots \\ a_{r1} & a_{r2} & \cdots & a_{rc} \end{bmatrix}$$

Note that the maximum value for both r (number of rows) and c (number of columns) is 255.

- When you use the above procedure to directly assign data to a matrix, the dimensions (size) of the matrix is set automatically.
- A "Mem ERROR" message appears on the display if memory becomes full while you are substituting values in a matrix (page 332).
- You can also use the above procedure to input matrix data in a program.

• To specify the dimensions of a matrix and then input data

Example To set up a 2-row × 3-column matrix (Matrix B) and assign the following values to it.

$$\begin{pmatrix} 1 & 3 & 5 \\ -2 & 0 & 2 \end{pmatrix}$$

Display the matrix list.

[F4](LIST)

```
Mat Det Trn LIST SEE
```
[F4]

Use the [▲] and [▼] cursor keys to move the pointer to the matrix you want to use.

```
Matrix List
 Mat A   :2×3
▶Mat B   :None
EDIT DIM ERASE ERS-A
```
[F2]

Pointer

[F2](DIM)

```
Set Dimension
MAT B
 Row  : 0
 Colum: 0
```

Specify the number of rows and columns you want to use, pressing [EXE] after each input.

[2] [EXE]
[3] [EXE]

```
Set Dimension
MAT B
 Row  : 2
 Colum: 3
```

Press [EXIT] to return to the matrix list.

```
Matrix List
 Mat A   :2×3
▶Mat B   :2×3
```

- If the matrix couldn't be created because of lack of memory, "None" appears in the matrix list in place of the dimension (2 × 3).
- Note that you could end the procedure here if you want to.

After making sure that the pointer is located next to the matrix you want to use, press [F1](EDIT).

[F1](EDIT)

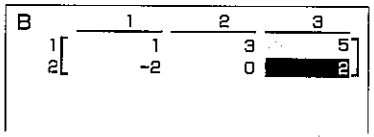
```
B      1      2      3
1[     0      0      0]
2[     0      0      0]

                     0
RwOp ROW COL
```

Important

Note that if you input data into a matrix that already contains data, the previous data is replaced with the new data.

Input the value for each cell, pressing [EXE] each time.

[1][EXE][3][EXE][5][EXE]
[(−)][2][EXE][0][EXE][2][EXE]



After inputting all of the values, press [EXIT] to return to the matrix list.

- Each cell can hold a value that is eight digits long if positive, or seven digits long if negative. With exponential display, only two significant digits are used.
- You can use the cursor keys to move the highlighting around the display for correction of input values, etc.
- Ten bytes of memory are required for each cell. This means that inputting data into a 3 × 3 matrix uses up 90 bytes (3 × 3 cells × 10 bytes = 90 bytes) of memory.

■Deleting Matrices

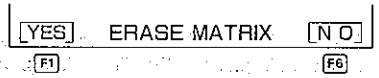
You can delete a specific matrix or all of the matrices stored in memory.

• To delete a specific matrix

Display the matrix list.
Move the pointer next to the matrix you want to delete.

Press [F3](ERASE).

[F3](ERASE)



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

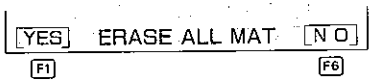
- After you delete a matrix, the word "None" appears to the right of its location in the matrix list.

• To delete all matrices

Display the matrix list.

Press [F4](ERS•A).

[F4](ERS•A)



Press [F1](YES) to delete all matrices, or [F6](NO) to abort the operation without deleting anything.

6-2 Modifying a Matrix

Once you create a matrix, you can perform any of the following operations to modify it.

- **Swapping of any two rows**
- **Calculation of a scalar product**
- **Scalar product addition**
- **Substitution and recall of values**
- **Row delete, insert, add**
- **Column delete, insert, add**

■Before Modifying a Matrix

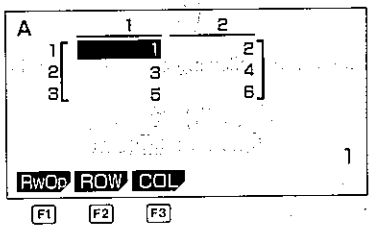
Before starting work with an existing matrix, you must first select it in the matrix list and then display the matrix editing screen.

• To display the matrix editing screen

Example **To display Matrix A, which contains the following data.**

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

[MENU](MAT)[EXE]
[F4](LIST)
[F1](EDIT)



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](RwOp) ..... Display of menu for swapping of rows, scalar products and addition
[F2](ROW) ..... Display of menu for deleting, inserting, and adding rows
[F3](COL) ..... Display of menu for deleting, inserting, and adding columns

■Row Operations

The row operations menu lets you swap any two rows, calculate scalar products, add scalar products to another row, and add rows together. Use the following procedure to display the row operation menu.

• To display the row operation menu

In the Matrix Mode, display the matrix list and select the matrix you want to work with.

[F4](LIST)[▼]

Display the matrix editing screen.

[F1](EDIT)

Display the row operation menu.

[F1](RwOp)

Swap	XRw	xRw+	Rw+
[F1]	[F2]	[F3]	[F4]

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](Swap) ..... Swapping of rows
[F2](×Rw) ..... Calculation of scalar products for specific rows
[F3](×Rw+) ..... Addition of the scalar product of one row to another row
[F4](Rw+) ..... Addition of one row to another

• To swap two rows

Example **To swap rows two and three in the following matrix (Matrix A).**

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

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F1](RwOp) [F1](Swap)

```
m? _
Swap Row m↔Row n
```


Input the numbers of the rows you want to swap.

[2][EXE]
[3][EXE]

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

• To calculate a scalar product for a row

Example **To calculate the scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4.**

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

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F1](RwOp) [F2](×Rw)

```
k? _
k×Row m→Row m
```

Input the numbers you want to multiply by and the number of the row whose scalar product you want to calculate.

[4][EXE]
[2][EXE]

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

• To add the scalar product of one row to another row

Example **To calculate the scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4, and then add the results to row 3.**

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

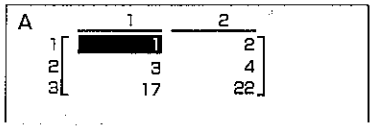
Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F1](RwOp) [F3](×Rw+)

```
k? _
k×Row m+Row n→Row n
```

Input the numbers you want to multiply by, followed by the number of the row whose scalar product you want to calculate, and then the number of the row you want the results added to.

4 EXE
2 EXE
3 EXE



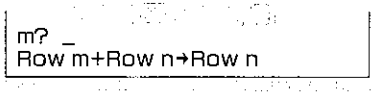
• To add one row to another

Example **To add row 2 to row 3 in the following matrix (Matrix A), and store the result in row 3.**

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

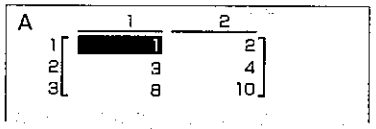
Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F1(RwOp) F4(Rw+)



Input the number of the first row and then the number of the second row. The result will be stored in the second row.

2 EXE
3 EXE



■Modifying the Contents of a Matrix

You can specify a value for direct substitution in a matrix cell, and you can recall values from a specific cell to perform arithmetic operations on that value.

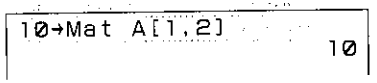
• To directly substitute value in a matrix cell

Example **To substitute a value of 10 in row 1 column 2 of the following matrix (Matrix A).**

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

Perform the following operation while in the Matrix Mode.

10 →F1(Mat) ALPHA A
ALPHA [1 SHIFT , 2 ALPHA]
EXE



The following is the basic format for the above procedure.
Mat X [r, c]
X = Matrix name (A through Z, or Ans)
r = row number
c = column number

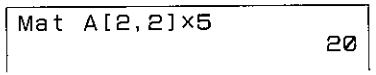
• To perform an arithmetic operation using a matrix value

Example **To multiply the value located at row 2, column 2 in the following matrix (Matrix A) by 5.**

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

Perform the following operation while in the Matrix Mode.

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



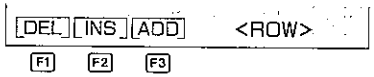
■Deleting, Inserting, and Adding Rows

Use the following procedures to delete, insert and add rows in a matrix.

Before starting a row delete, insert or add operation, you must first select the matrix you want to work with and then press F2(ROW) to display the row editing screen.

First, select and recall the matrix you want to edit.
MENU(MAT) EXE
F4(LIST) F1(EDIT)

Next, press [F2](ROW) to display the row editing screen.



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

[F1](DEL) ..... Row deletion
[F2](INS) ..... Row insertion
[F3](ADD) ..... Row addition

• To delete a row

Example **To delete row 2 of the following matrix (Matrix A).**

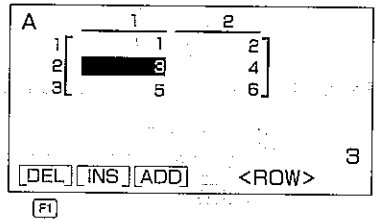
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F2](ROW)

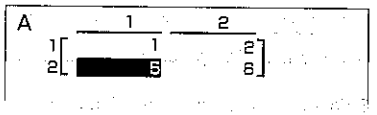
Move the highlighting into the row you want to delete.

[▼]



Perform the delete operation.

[F1](DEL)



• To insert a row

Example **To insert a row between rows 1 and 2 of the following matrix (Matrix A).**

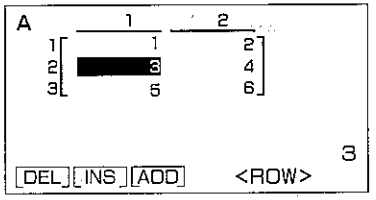
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F2](ROW)

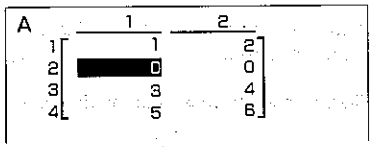
Move the highlighting into the row that you want to be below the newly inserted row.

[▼]



Perform the insert operation.

[F2](INS)



• To add a row

Example **To add a row below row 3 of the following matrix (Matrix A).**

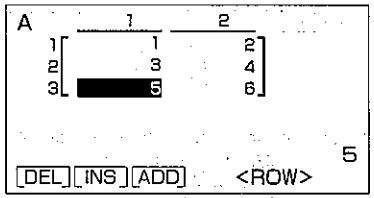
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F4](LIST) [F1](EDIT)
[F2](ROW)

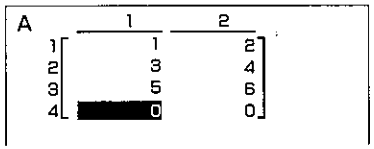
Move the highlighting into the row that you want to be above the newly added row.

(▼)(▼)



Perform the add operation.

F3(ADD)



■Deleting, Inserting, and Adding Columns

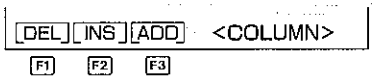
Use the following procedures to delete, insert and add columns in a matrix.

Before starting a column delete, insert or add operation, you must first select the matrix you want to work with and then press F3(COL) to display the column editing screen.

First, select and recall the matrix you want to edit.

MENU(MAT) EXE
F4(LIST) F1(EDIT)

Next, press F3(COL) to display the column editing screen.



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

F1(DEL) ..... Column deletion
F2(INS) ..... Column insertion
F3(ADD) ..... Column addition

• To delete a column

Example **To delete column 2 of the following matrix (Matrix A).**

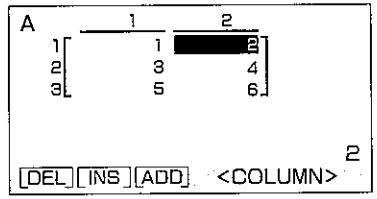
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F3(COL)

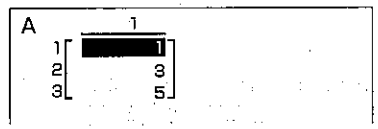
Move the highlighting into the column you want to delete.

(▶)



Perform the delete operation.

F1(DEL)



• To insert a column

Example **To insert a column between columns 1 and 2 of the following matrix (Matrix A).**

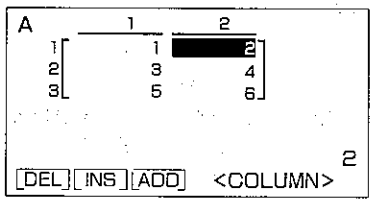
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F3(COL)

Move the highlighting into the column that you want to be to the right of the newly inserted column.

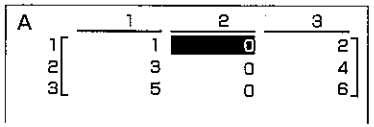
▶



F2

Perform the insert operation.

F2(INS)



• To add a column

Example **To add a column to the right of column 2 of the following matrix (Matrix A).**

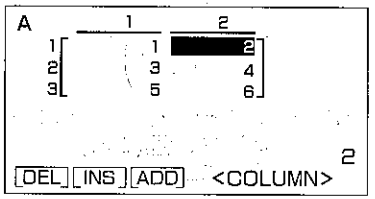
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

F4(LIST) F1(EDIT)
F3(COL)

Move the highlighting into the column that you want to be to the left of the newly added column.

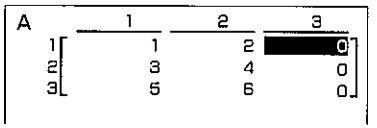
▶



F3

Perform the add operation.

F3(ADD)



6-3 Matrix Calculations

This section describes how to actually perform matrix calculations. To perform a calculation, you must press the Matrix Mode function key (page 112) that puts in the correct calculation mode. The following shows the modes you can enter and the function keys you should press to enter the modes.

F1(Mat) ..... For specification of matrix type
F2(Det) ..... Determinant
F3(Trn) ..... Transposition

■Arithmetic Operations

Use the procedures described here to add, subtract, and multiply matrices. Note that you cannot use division with matrices.

• To add matrices

Example **To add the following two matrices.**

Matrix A $\begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix}$ **Matrix B** $\begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$

Perform the following operation while in the Matrix Mode.

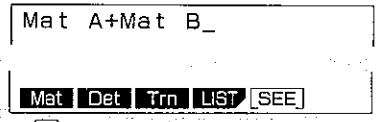
F1(Mat)

Input the name of the first matrix.

ALPHA A +
F1(Mat)

Input the name of the second matrix.

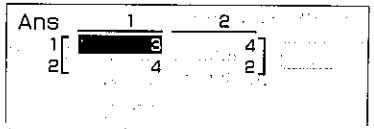
ALPHA B



F1

Execute the operation and display its result.

EXE



The display shows that **Matrix A** + **Matrix B** = $\begin{pmatrix} 3 & 4 \\ 4 & 2 \end{pmatrix}$.

*The dimensions (sizes) of the two matrices being added must be identical. If you try to add matrices of different dimensions, a "Dim ERROR" will occur.

• To subtract matrices

Example **To subtract Matrix B from Matrix A. The following shows the contents of the two matrices.**

$$\text{Matrix A} \begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix} \qquad \text{Matrix B} \begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F1](Mat)

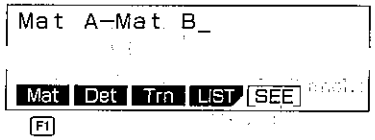
Input the name of the matrix you want to subtract from.

[ALPHA][A][−]

[F1](Mat)

Input the name of the matrix you want to subtract.

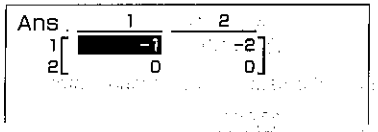
[ALPHA][B]



[F1]

Execute the operation and display its result.

[EXE]



The display shows that **Matrix A − Matrix B** = $\begin{pmatrix} -1 & -2 \\ 0 & 0 \end{pmatrix}$.

*The dimensions (sizes) of the two matrices being subtracted must be identical. If you try to subtract matrices of different dimensions, a "Dim ERROR" will occur.

• To multiply matrices

Example **To multiply Matrix B by Matrix A. The following shows the contents of the two matrices.**

$$\text{Matrix A} \begin{pmatrix} 1 & 1 \\ 2 & 1 \end{pmatrix} \qquad \text{Matrix B} \begin{pmatrix} 2 & 3 \\ 2 & 1 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F1](Mat)

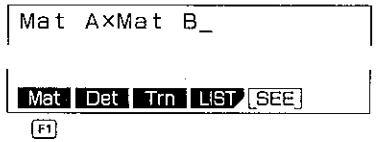
Input the name of the matrix you want to multiply.

[ALPHA][A][×]

[F1](Mat)

Input the name of the matrix you want to multiply by.

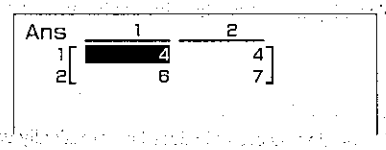
[ALPHA][B]



[F1]

Execute the operation and display its result.

[EXE]



The display shows that **Matrix A × Matrix B** = $\begin{pmatrix} 4 & 4 \\ 6 & 7 \end{pmatrix}$.

*The dimensions (sizes) of the two matrices being multiplied must be identical. If you try to multiply matrices of different dimensions, a "Dim ERROR" will occur.

■ Calculating a Scalar Product

To calculate a scalar product, you specify the multiplier and then the matrix name (Matrix A to Matrix Z, or Mat Ans). Next you press the [EXE] key to perform the multiplication.

• To calculate a scalar product

Example **To calculate the scalar product for the following matrix (Matrix A) by multiplying by 4.**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

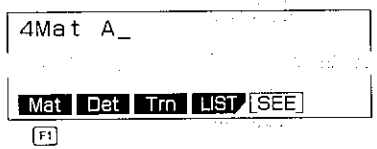
Perform the following operation while in the Matrix Mode.

Input the multiplier.

[4]

Specify the name of the matrix you want to multiply.

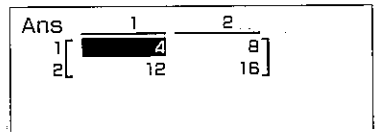
[F1](Mat)[ALPHA][A]



[F1]

Execute the operation and display the matrix where the result is stored.

[EXE]



The display shows that the **scalar product of Matrix A** is $\begin{pmatrix} 4 & 8 \\ 12 & 16 \end{pmatrix}$.

■Determinants

Determinants are calculated automatically using the formulas shown below. Note that after you calculate a determinant, you can assign it to a value memory.

•2 × 2 matrix

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

$$= a_{11}a_{22} - a_{12}a_{21}$$

•3 × 3 matrix

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

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

• To calculate a determinant

Example **To calculate the determinant for the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ -1 & -2 & 0 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

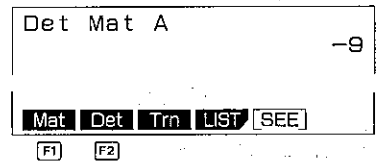
[F2](Det)
[F1](Mat)

Input the name of the matrix whose determinant you want to calculate.

[ALPHA][A]

Execute the operation and display the result.

[EXE]



[F1] [F2]

The display shows that the **determinant of Matrix A = -9.**

*Note that you can calculate the determinant for square matrices (same number of rows and columns) only. Attempting to calculate the determinant for a matrix that is not square results in a "Dim ERROR."

■Transposing a Matrix

Transposing a matrix causes its rows to become columns and its columns to become rows. You can transpose any matrix in the matrix list (Matrix A through Matrix Z) or the matrix in the Matrix Answer Memory.

• To transpose a matrix

Example **To transpose the following matrix (Matrix A).**

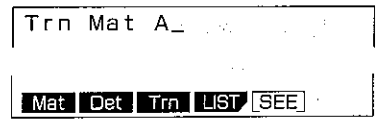
$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \\ 5 & 6 \end{pmatrix}$$

Perform the following operation while in the Matrix Mode.

[F3](Trn)

Specify the name of the matrix you want to transpose.

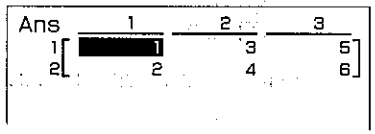
[F1](Mat)[ALPHA][A]



[F1] [F3]

Execute the operation and display the transposed matrix.

[EXE]



The display shows that **transposing Matrix A produces** $\begin{pmatrix} 1 & 3 & 5 \\ 2 & 4 & 6 \end{pmatrix}$.

■Inverting a Matrix

Matrices are inverted automatically according to the following rules, where A is a matrix and A^{-1} is its inverse.

- A matrix being inverted must satisfy the following conditions

$$A A^{-1} = A^{-1} A = E = \begin{pmatrix} 1 & 0 \\ 0 & 1 \end{pmatrix}$$

- The following shows the formula use to invert Matrix A, shown below, into inverse matrix A^{-1}.

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

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

In the above: $ad - bc \neq 0$

• To invert a matrix

Example **To invert the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

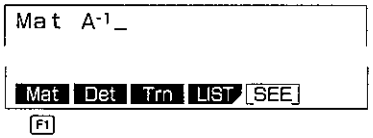
Perform the following operation while in the Matrix Mode.

Specify the name of the matrix you want to invert.

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

Specify matrix inversion.

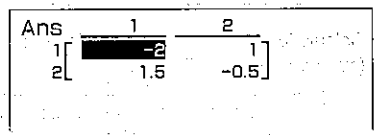
[SHIFT][x^{-1}]



[F1]

Execute the operation and display the inverted matrix.

[EXE]



The display shows that **inverting Matrix A produces** $\begin{pmatrix} -2 & 1 \\ 1.5 & -0.5 \end{pmatrix}$.

*Note that a matrix cannot be inverted if the determinant is zero. Attempting to invert such a matrix results in an "Ma ERROR."

*Note that you can only invert square matrices, which have the same number of rows and columns. Attempting to invert a matrix that is not square results in a "Dim ERROR."

■Squaring a Matrix

Use the operations described below to square a matrix.

• To square a matrix

Example **To square the following matrix (Matrix A).**

$$\begin{pmatrix} 1 & 2 \\ 3 & 4 \end{pmatrix}$$

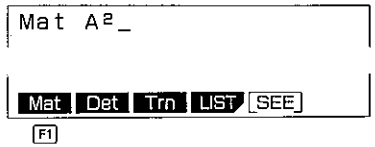
Perform the following operation while in the Matrix Mode.

Specify the name of the matrix you want to square.

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

Specify squaring.

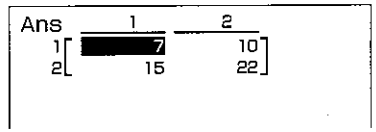
[x^2]



[F1]

Execute the operation and display the squaring matrix.

[EXE]



The display shows that **squaring Matrix A produces** $\begin{pmatrix} 7 & 10 \\ 15 & 22 \end{pmatrix}$.

6-4 Matrix Operation Precautions

- Calculation of determinants and inverse matrices uses the elimination method, so errors (such as dropped digits) may be generated.
- The results of matrix calculations are stored into the Matrix Answer Memory (Mat Ans). The Matrix Answer Memory dimensions are automatically adjusted to accommodate the result. Note that storage of a new result causes the previous Answer Matrix Memory contents to be deleted.
- Matrix operations are performed individually on each element, and so calculation may require considerable time.
- The calculation precision of matrix calculations is 12 digits, ±1.
- If a matrix calculation result becomes too large to fit into the Matrix Answer Memory (Mat Ans), a "Mem ERROR" occurs.
- You can transfer the contents of the Answer Matrix Memory to another matrix (or variable when the Answer Matrix Memory contains a matrix formula). The following input is also possible:

  Mat α + (or −, ×) Mat β → Mat γ
  kMat α → Mat β
  Det Mat α → X
  Trn Mat α → Mat β
  Mat α^{-1} → Mat β
  Mat α^2 → Mat β

  With the above input, α = variable A through Z; X = variable A through Z, $\overline{r}$, or θ.
  Note that when you transfer the contents of the Answer Matrix Memory to another matrix, the original contents of the Answer Matrix Memory are unchanged.

Chapter 7

Equation Calculations

Chapter 7 Equation Calculations

Your graphic calculator can solve the following three types of equations:

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

7-1 Before Beginning an Equation Calculation

Before beginning an equation calculation you have to first enter the correct mode, and you must also clear the equation memories of any data that might be left over from a previous calculation.

■To Enter an Equation Calculation Mode

Highlight the **EQUA** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the Equation (EQUA) Mode.

[EXE]

```
EQUATION
angle    :Deg
display:Norml
M-D/Cpy:M-Disp
F1:SIMULTANEOUS
F2:POLYNOMIAL

 SIML  POLY
```

[F1] [F2]

The following are the types of equations that can be selected from the function menu at the bottom of the display. Press the function key below the type of equation you want to solve.

[F1](SIML) ..... Linear equation with two to six unknowns
[F2](POLY) ..... Quadratic or cubic equation

■To Clear the Equation Memories

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

```
 SOLV  CLER  ERASE
```

[F3]

[F3](ERASE)

```
 YES  ERASE EQUATION ? NO
```

[F1] [F6]

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

7-2 Linear Equations with Two to Six Unknowns

You can use the procedures described here to solve linear equations with unknowns that match the following formats:

- **Two unknowns**

$$\begin{aligned} a_1x + b_1y &= c_1 \\ a_2x + b_2y &= c_2 \end{aligned}$$

- **Six unknowns**

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

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

■To Enter the Linear Equation Mode for Two to Six Unknowns

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

[F1](SIML)

```
SIMULTANEOUS
No data in memory



Number of unknowns?
 2  3  4  5  6
```

[F1] [F2] [F3] [F4] [F5]

The following are the operations that are available from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

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

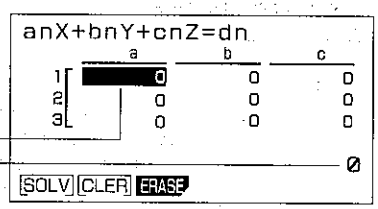
■To Solve a Linear Equation with Three Unknowns

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

$4x+y-2z=-1$
$x+6y+3z=1$
$-5x+4y+z=-7$

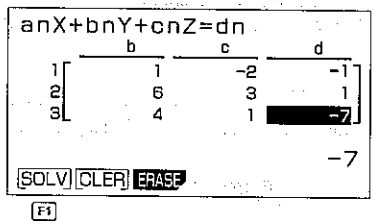
While in the Linear Equation Mode (SIML), press [F2] (3), because the linear equations being solved have three unknowns.

[F2](3)



Input each coefficient.

[4] [EXE] [1] [EXE] [(–)] [2] [EXE]
[(–)] [1] [EXE]
[1] [EXE] [6] [EXE] [3] [EXE] [1] [EXE]
[(–)] [5] [EXE] [4] [EXE] [1] [EXE]
[(–)] [7] [EXE]



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

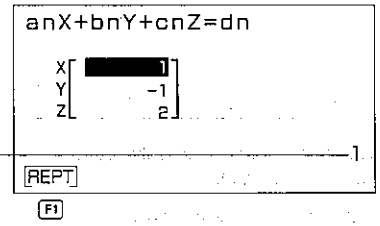
coefficient a_1 → coefficient b_1 → coefficient c_1 →
coefficient a_2 → coefficient b_2 → coefficient c_2 →
coefficient a_3 → coefficient b_3 → coefficient c_3

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

After inputting the coefficients, solve the equations.

[F1](SOLV)

Highlighted solution cell value



•Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 12-digit mantissa and 2-digit exponent.
•This unit performs simultaneous linear equations by placing the coefficients inside of a matrix. Because of this, as the coefficient matrix approaches zero, precision in the inverse matrix is reduced and so precision in the results produced also deteriorates. For example, the solution for a linear equation with three unknowns would be calculated as shown below.

$$\begin{bmatrix} x \\ y \\ z \end{bmatrix} = \begin{bmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{bmatrix}^{-1} \begin{bmatrix} d_1 \\ d_2 \\ d_3 \end{bmatrix}$$

•An "Ma ERROR" occurs whenever the unit is unable to solve the equations.
•Pressing [F1] (REPT) returns to the initial display of the Linear Equation Mode.

Depending on the coefficients that you use, it may take considerable time for the calculation result of simultaneous linear equations to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

■Changing Coefficients

You can change a coefficient either before or after you register it by pressing [EXE].

• To change a coefficient before registering it with [EXE]

Press the [AC] key to clear the current value and then input another one.

• To change a coefficient after registering it with [EXE]

Use the cursor keys to highlight the cell that contains the coefficient that you want to change. Next, input the value that you want to change to.

■To Clear All the Coefficients

While in the Linear Equation Mode, press the [F2] (CLER) function key. This operation clears all the coefficients to zero.

[F2](CLER)

7-3 Quadratic and Cubic Equations

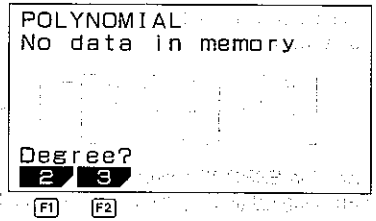
This calculator can also solve quadratic and cubic equations that match the following formats (when $a \neq 0$):

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

■To Enter the Quadratic/Cubic Equation Mode

While the Equation Mode is displayed, press [F2](POLY).

[F2](POLY)



The following are the operations that are available from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

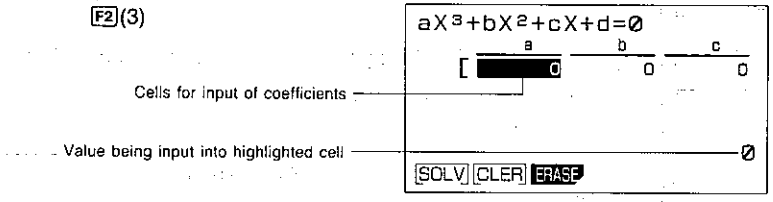
[F1](2) ..... Quadratic equation
[F2](3) ..... Cubic equation

■To Solve a Quadratic or Cubic Equation

Example **To solve the following cubic equation:**
$x^3 - 2x^2 - x + 2 = 0$

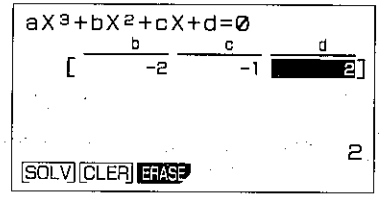
While in the Quadratic or Cubic Equation Mode (POLY), press [F2] (3) to enter the Cubic Equation Mode.

[F2](3)



Input each coefficient.

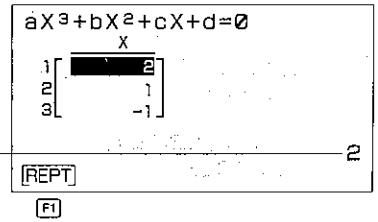
[1] [EXE] [(−)] [2] [EXE]
[(−)] [1] [EXE] [2] [EXE]



- Each time you press [EXE], the input value is registered in the highlighted cell. Each press of [EXE] inputs values in the following sequence:
  coefficient a → coefficient b → coefficient c → coefficient d
  Input for coefficient d is required only input for cubic equations.
- You can input fractions and value memory contents as coefficients.

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

[F1](SOLV)



- Internal calculations are performed using a 15-digit mantissa, but results are displayed using a 12-digit mantissa and 2-digit exponent.
- An "Ma ERROR" occurs whenever the unit is unable to solve the equations.
- Pressing [F1] (REPT) returns to the initial display of the Quadratic Equation Mode.

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

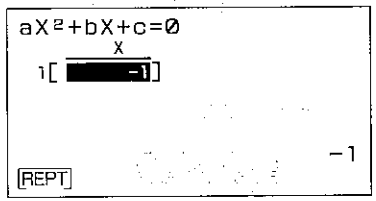
The following examples illustrate how multiple-root solutions and imaginary number solutions are handled.

• To solve a quadratic equation that produces a single-value solution

Example To solve the following quadratic equation:

$x^2 + 2x + 1 = 0$

1 EXE 2 EXE 1 EXE
F1(SOLV)

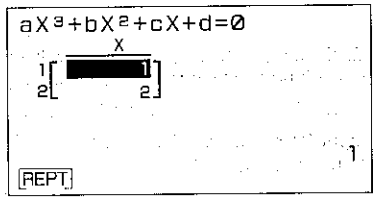


• To solve a cubic equation that produces a multiple-value solution

Example To solve the following cubic equation:

$x^3 - 4x^2 + 5x - 2 = 0$

1 EXE (-) 4 EXE 5 EXE (-) 2 EXE
F1(SOLV)

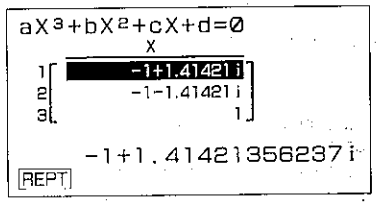


• To solve a cubic equation that produces an imaginary number solution

Example To solve the following cubic equation:

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

1 EXE 1 EXE 1 EXE (-) 3 EXE
F1(SOLV)



It may take considerable time for the calculation result of cubic equations to appear on the display. Failure of a result to appear immediately does not mean that the unit is not functioning properly.

■Changing Coefficients

You can change a coefficient either before or after you register it by pressing EXE.

• To change a coefficient before registering it with EXE

Press the AC key to clear the current value and then input another one.

• To change a coefficient after registering it with EXE

Use the cursor keys to highlight the cell that contains the coefficient that you want to change. Next, input the value that you want to change to.

■To Clear All the Coefficients

While in the Quadratic or Cubic Equation Mode, press the F2(CLER) function key. This operation clears all the coefficients to zero.

F2(CLER)

7-4 What to Do When an Error Occurs

• Error during coefficient value input

Press the AC key to clear the error and return to the value that was registered for the coefficient before you input the value that generated the error. Try inputting a new value again.

• Error during calculation

Press the AC key to clear the error and display coefficient a. Try inputting values for the coefficients again.

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

Chapter 8

Graphing

Chapter 8 Graphing

This chapter explains everything you need to know to fully use the versatile graphing capabilities of the unit.

8-1 About the Graphing Function

The large 127 × 63 dot display of the unit provides you with the capability to graph the following:

Rectangular coordinates
Polar coordinates
Parametrics
Inequalities
Integrations
Probability distributions
Single-variable statistics
Paired-variable statistics

These graphs can be produced using manual input or by programs.
You should enter the COMP, SD, REG, MAT, TABLE, GRAPH or DYNA Mode to perform the operations described in this section.

Note that the same manual procedures described here can be used inside programs to draw graphs. For details, see page 292.

■Specifying the Range of a Graph

Before you draw a graph, you must first use the Range Parameter Screen to specify the range parameters of the graph.

• To display the Range Parameter Screen

[Range]

Rectangular Coordinate Range Screen

Xmin — minimum value of *x*-coordinate
Xmax — maximum value of *x*-coordinate
Xscale — scale of *x*-coordinate
Ymin — minimum value of *y*-coordinate
Ymax — maximum value of *y*-coordinate
Yscale — scale of *y*-coordinate

```
Range
Xmin   : -5
 max   : 5
 scale : 2
Ymin   : -10
 max   : 10
 scale : 5
[INIT] [TRIG]
```


[Range]

Polar Coordinate Range Screen

T, θ min — minimum value of T/θ
T, θ max — maximum value of T/θ
T, θ pitch — pitch of T/θ

```
Range
T, θ
 min   : 0
 max   : 360
 pitch : 3.6
[INIT] [TRIG]
```

• To specify range parameters

Example To specify the following range parameters

Xmin	0
Xmax	5
Xscale	1
Ymin	−5
Ymax	15
Yscale	5
T, θ min	0
T, θ max	4π
T, θ pitch	π ÷ 36

① [0] [EXE]

```
Range
Xmin   : 0
 max   : 5
 scale : 2
Ymin   : -10
 max   : 10
 scale : 5
[INIT] [TRIG]
```

② [EXE]

```
Range
Xmin   : 0
 max   : 5
 scale : 2
Ymin   : -10
 max   : 10
 scale : 5
[INIT] [TRIG]
```

③ [1] [EXE]

```
Range
Xmin   : 0
 max   : 5
 scale : 1
Ymin   : -10
 max   : 10
 scale : 5
[INIT] [TRIG]
```

④ [(−)] [5] [EXE]

```
Range
Xmin   : 0
 max   : 5
 scale : 1
Ymin   : -5
 max   : 10
 scale : 5
[INIT] [TRIG]
```

⑤ [1][5][EXE]

```
Range
Xmin  : 0
 max  : 5
 scale: 1
Ymin  : -5
 max  : 15
 scale: 5
[INIT][TRIG]
```

⑥ [EXE]

```
Range
T,θ
 min  : 0
 max  : 360
 pitch: 3.6
[INIT][TRIG]
```

⑦ [EXE]

```
Range
T,θ
 min  : 0
 max  : 360
 pitch: 3.6
[INIT][TRIG]
```

⑧ [4][SHIFT][π][EXE]

```
Range
T,θ
 min  : 0
 max  : 4π
 pitch: 3.6
[INIT][TRIG]
```

⑨ [SHIFT][π][÷][3][6]

```
Range
T,θ
 min  : 0
 max  : 4π
 pitch: π÷36_
[INIT][TRIG]
```

Pressing [Range], [EXIT], or [SHIFT][QUIT] clears the Range Parameter Display. Next, you can use [Range] to confirm that your parameters are correct.

⑩ [Range]

```
Range
Xmin  : 0
 max  : 5
 scale: 1
Ymin  : -5
 max  : 15
 scale: 5
[INIT][TRIG]
```

⑪ [Range]

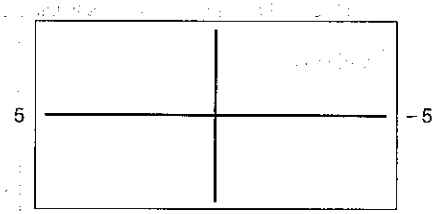
```
Range
T,θ
 min  : 0
 max  : 12.566370614
 pitch: 0.0872664625
[INIT][TRIG]
```

Note that the π and division operations we entered above have been automatically converted to the correct values.

- You can set range parameters within the range of $-9.99999E+97$ to $9.999999E+97$.

- Input values can have up to 12 significant digits. Values less than 10^{-2} and greater than 10^{7} are displayed with a 7-digit mantissa (including the negative sign) and a 2-digit exponent.
- The only input that is valid for range parameter input are numbers from 0 through 9, decimal points, EXP, (−), ◀, ▶, ▲, ▼, +, −, ×, ÷, (,) and π. You can also use [Range], [EXIT], [SHIFT][QUIT], but no other key operation is valid. Note that negative values are indicated using (−) or −.
- You cannot specify 0 for Xscale or Yscale.
- If you input an illegal value, the previous parameter is retained without change.
- If a minimum is greater than a maximum parameter, the axis is inverted.

Example **Xmin :5**
Xmax : −5



- Make sure that the cursor is at the far left of the line you are inputting before you start to input a range parameter value.

Example

```
Range
Xmin  : -25
 max  : 25
```

▶

```
Range
Xmin  : -25
 max  : 25
```

AC

```
Range
Xmin  :
 max  : 25
```

(−)[3][EXE]

```
Range
Xmin  : -3
 max  : 25
```

- You can input range parameters as expressions (such as 2π).
- When a range setting that does not allow display of the axes is used, the scale for the y-axis is indicated on either the left or right edge of the display, while that for the x-axis is indicated on either the top or bottom edge.

•When range values are changed, the graph display is cleared and the newly set axes only are displayed.
•Range setting may cause irregular scale spacing.
•If the range is set too wide, the graph produced may not fit on the display.
•The point of deflection sometimes exceeds the capabilities of the display with graphs that change drastically as they approach the point of deflection.
•A range that is too small can cause an "Ma ERROR".

■Initializing the Range Parameter Display Settings

There are two methods that you can use to initialize the Range Parameter Display settings.

● [Range][F1](INIT)

```
Range
Xmin  : -6.3
 max  :  6.3
 scale:  1
Ymin  : -3.706
 max  :  3.706
 scale:  1
[INIT][TRIG]
```

● [Range][F2](TRIG)

This operation performs initialization in accordance with the current unit of angular measurement mode (Deg, Rad, or Gra). This initialization operation is helpful when drawing trigonometric graphs.

Deg Mode

```
Range
Xmin  : -540
 max  :  540
 scale:  90
Ymin  : -1.6
 max  :  1.6
 scale:  0.5
[INIT][TRIG]
```

Rad Mode

```
Range
Xmin  : -9.42477796
 max  :  9.4247779607
 scale:  1.5707963267
```

Gra Mode

```
Range
Xmin  : -600
 max  :  600
 scale:  100
```

•The settings for Y min, Y max, Y pitch, T/θ min, T/θ max, and T/θ pitch remain unchanged when you press [F2](TRIG).

● To specify range parameters within a program

Use the following format to specify range parameters in a program.

Range (value of Xmin), (value of Xmax), (value of Xscale),
(value of Ymin), (value of Ymax), (value of Yscale),
(value of T/θmin), (value of T/θmax), (value of T/θpitch)

8-2 Rectangular Coordinate Graphs

Use the RECT mode to draw rectangular coordinate graphs.

■Graphing Built-in Scientific Functions

The following is a list of the built-in scientific functions that you can graph.

•$\sin x$	•$\cos x$	•$\tan x$	•$\sin^{-1}x$	•$\cos^{-1}x$	•$\tan^{-1}x$
•$\sinh x$	•$\cosh x$	•$\tanh x$	•$\sinh^{-1}x$	•$\cosh^{-1}x$	•$\tanh^{-1}x$
•$\sqrt{x}$	•x^2	•$\log x$	•$\ln x$	•10^x	•e^x
•x^{-1}	•$\sqrt[3]{x}$				

Use the RUN/COMP Mode to draw rectangular coordinate graphs. Do not use the BASE, EQUA, DYNA or TABLE Mode. When you graph a built-in function, the range parameters are set by the unit automatically.

Select COMP from the main menu, and then use the set up display to specify RECT as the graph type.

[SHIFT][SETUP][F1](RECT)

```
▶GRAPH TYPE  :RECT
 DRAW TYPE   :CONNECT
```

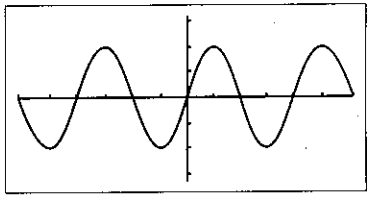
[EXIT]

Next, draw the graph.

[Graph] **[any function key]** [EXE]

● To graph the sine function

[Graph][sin][EXE]



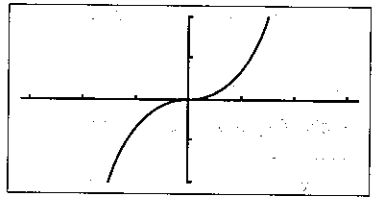
■Overdrawing Built-in Function Graphs

You can draw two or more built-in function graphs on the same screen. The range of first graph is set automatically, and the same range is applied for subsequent graphs. The important thing to note in the following example is the use of [X,θ,T]. By pressing [X,θ,T] before [EXE] to graph the second function, you are telling the unit to leave the previously drawn graphs on the display. If you do not press [X,θ,T], the unit will clear the graphic display automatically and graph only the last function you entered.

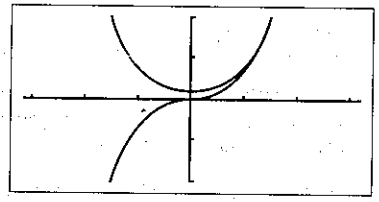
• To overdraw graphs

Example **To graph $y = \sinh x$ and overdraw it with $y = \cosh x$:**

[SHIFT] [F5] (Cls) [EXE]
[Graph] [SHIFT] [MATH] [F1] (HYP)
[F1] (sinh) [EXE]



[Graph] [F2] (cosh) [X,θ,T] [EXE]



Note

You cannot use built-in function graphs in multistatements (page 31) and programming.

■Graphing Manually Entered Functions

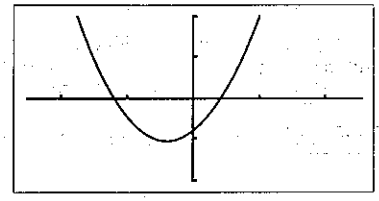
You can graph manually entered functions by simply pressing [Graph] and then entering the function. Remember that you also have to specify range parameters (page 147).

• To graph a manually entered function

Example **To graph $y = 2x^2 + 3x - 4$ using the following range parameters:**

```
Range
Xmin   : -5
 max   : 5
 scale : 2
Ymin   : -10
 max   : 10
 scale : 5
[INIT] [TRIG]
```


[SHIFT] [F5] (Cls) [EXE]
[Graph] [2] [X,θ,T] [x^2] [+] [3] [X,θ,T] [−]
[4] [EXE]



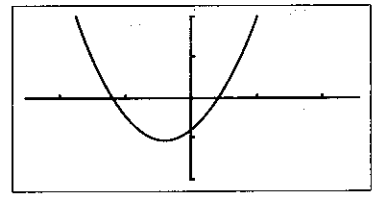
■Overdrawing Manually Input Graphs

You can draw two or more manually input graphs on the same screen. This makes it possible to find points of intersection and solutions at a glance.

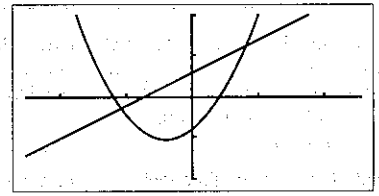
• To overdraw manually entered graphs

Example **To graph $y = 2x^2 + 3x - 4$ and overdraw it with $y = 2x + 3$:**

[SHIFT] [F5] (Cls) [EXE]
[Graph] [2] [X,θ,T] [x^2] [+] [3] [X,θ,T] [−]
[4] [EXE]



[Graph] [2] [X,θ,T] [+] [3] [EXE]



Later you will learn how to use the Trace Function (page 186) to find out the values at the points of intersection.

■Specifying the Value Range

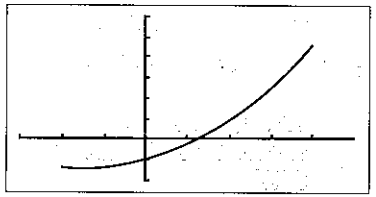
When graphing a function with the format "y = function", you can specify the maximum and minimum values to be applied. Use the following format.

Graph **function** SHIFT , ALPHA [**Xmin** SHIFT , **Xmax** ALPHA] EXE

Example **To graph $y=x^2+3x-5$ for the range $-2 \leqq x \leqq 4$:**

```
Range
Xmin   : -3
 max   : 5
 scale : 1
Ymin   : -10
 max   : 30
 scale : 5
INIT TRIG
```

SHIFT F5 (Cls) EXE
Graph X,θ,T x² + 3 X,θ,T −
5 SHIFT , ALPHA [(−) 2
SHIFT , 4 ALPHA] EXE



8-3 Polar Coordinate Graphs

After you change from the RECT Mode to the POL Mode, you can use the unit to draw polar coordinate graphs. When you graph a built-in function, the range parameters are set by the unit automatically. The functions that can be graphed in the POL Mode are those that fit the following format:

$r = \mathbf{f}(\theta)$

Note that you should specify **rads** as the unit of angular measurement when graphing polar coordinate graphs.

■Graphing Built-In Scientific Functions

Use the RUN/COMP Mode to draw polar coordinate graphs. Do not use the BASE, EQUA, DYNA or TABLE Mode. When you graph a built-in function, the range parameters are set by the unit automatically.

The following is a list of the built-in scientific functions that you can graph using polar coordinates.

$\sin\theta$	$\cos\theta$	$\tan\theta$	$\sin^{-1}\theta$	$\cos^{-1}\theta$	$\tan^{-1}\theta$
$\sinh\theta$	$\cosh\theta$	$\tanh\theta$	$\sinh^{-1}\theta$	$\cosh^{-1}\theta$	$\tanh^{-1}\theta$
$\sqrt{\theta}$	θ^2	$\log\theta$	$\ln\theta$	10^θ	e^θ	θ^{-1}	$\sqrt[3]{\theta}$

SHIFT SETUP F2 (POL)

```
▶GRAPH TYPE  :POL
 DRAW TYPE   :CONNECT
```

EXIT

Next, specify radians as the unit of angular measurement.

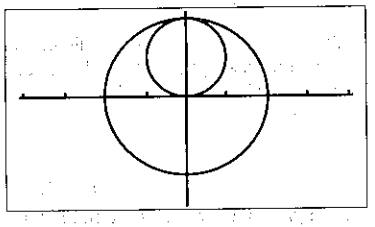
SHIFT DRG F2 (Rad) EXE

Now draw the graph.

Graph **[any function key]** EXE

Example **To graph tanh θ:**

Graph SHIFT MATH F1 (HYP) F3 (tanh) EXE



■Graphing Manually Entered Functions

You can graph manually entered functions by simply pressing Graph and then entering the function. Manually entered functions must have the following format:

Graph r = [θ function]

Remember that you also have to specify range parameters (page 147).

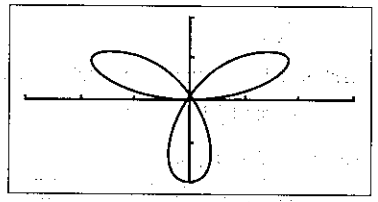
• To graph a manually entered function

Example **To graph $r = 2\sin 3\theta$ using the following range parameters:**

```
Range
Xmin   : -3
 max   : 3
 scale : 1
Ymin   : -2
 max   : 2
 scale : 1
INIT TRIG
```

```
Range
T, θ
 min   : 0
 max   : π
 pitch : π÷36

[INIT] [TRIG]
```

[SHIFT] [F5] (Cls) [EXE]
[Graph] [2] [sin] [3] [X,θ,T] [EXE]



Important

If the difference between the minimum and maximum values you set for the pitch of T or θ is too great, your graph will be too rough. If the difference is too small, drawing of the graph will take a very long time.

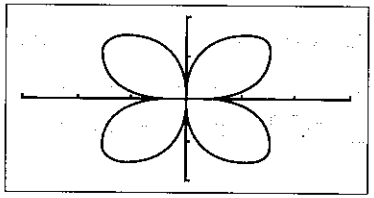
■Specifying the Value Range

When graphing a polar coordinate function, you can specify the maximum and minimum values to be applied. Use the following format.

[Graph] **function** [SHIFT] [,] [ALPHA] [[] **θmin** [SHIFT] [,] **θmax** [ALPHA] []] [EXE]

Example **To graph $r = 4\sin\theta\cos\theta$ for the range $-\pi \leqq \theta \leqq \pi$:**

[SHIFT] [F5] (Cls) [EXE]
[Graph] [4] [sin] [X,θ,T] [cos] [X,θ,T] [SHIFT] [,]
[ALPHA] [[] [(−)] [SHIFT] [π] [SHIFT] [,] [SHIFT] [π]
[ALPHA] [] [EXE]



8-4 Parametric Graphs

To draw parametric graphs, first change to the PARAM Mode. Do not try to use the BASE, EQUA, DYNA or TABLE Mode for graphing. The functions that can be graphed in the PARAM Mode are those that fit the following format:

$(x, y) = (f(T), g(T))$

[SHIFT] [SETUP] [F3] (PARM)

```
▶GRAPH TYPE  :PARAM
 DRAW TYPE   :CONNECT
```

[EXIT]

• To graph a parametric equation

Example **To graph the following functions:**

$x = 7\cos T - 2\cos 3.5T$

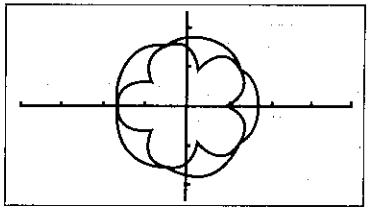
$y = 7\sin T - 2\sin 3.5T$

Use the following range parameters.

```
Range
Xmin  : -20
 max  : 20
 scale: 5
Ymin  : -12
 max  : 12
 scale: 5
[INIT] [TRIG]
```

```
Range
T, θ
 min   : 0
 max   : 4π
 pitch : π÷36

[INIT] [TRIG]
```

[SHIFT] [F5] (Cls) [EXE]
[SHIFT] [DRG] [F2] (Rad) [EXE]
[Graph] [7] [cos] [X,θ,T] [−] [2] [cos] [3] [·]
[5] [X,θ,T] [SHIFT] [,] [7] [sin] [X,θ,T] [−] [2]
[sin] [3] [·] [5] [X,θ,T] [)] [EXE]



Important

If the difference between the minimum and maximum values you set for the pitch of T or θ is too great, your graph will be too rough. If the difference is too small, drawing of the graph will take a very long time.

■Specifying the Value Range

When graphing a parametric function, you can specify the maximum and minimum values to be applied. Use the following format.

[Graph] **function** [SHIFT] [,] [ALPHA] [(] **Tmin** [SHIFT] [,] **Tmax** [ALPHA] [)] [EXE]

Example **To graph the following functions:**

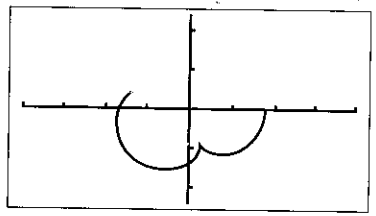
$x = 7\cos T - 2\cos 3.5T$

$y = 7\sin T - 2\sin 3.5T$

Use the following range:

$\pi \leqq T \leqq 2\pi$

[SHIFT] [F5] (Cls) [EXE]
[SHIFT] [DRG] [F2] (Rad) [EXE]
[Graph] [7] [cos] [X,θ,T] [−] [2] [cos] [3] [•] [5]
[X,θ,T] [SHIFT] [,] [7] [sin] [X,θ,T] [−] [2] [sin]
[3] [•] [5] [X,θ,T] [)] [SHIFT] [,] [ALPHA] [(]
[SHIFT] [π] [SHIFT] [,] [2] [SHIFT] [π] [ALPHA] [)]
[EXE]



8-5 Inequality Graphs

To draw inequality graphs, first change to the INEQ Mode. Do not try to use the BASE, EQUA, DYNA or TABLE Mode for graphing. The functions that can be graphed in the INEQ Mode are those that fit one of the following formats:

$Y > f(x)$ $\quad Y \geqq f(x)$
$Y < f(x)$ $\quad Y \leqq f(x)$

Important

Whenever drawing a new inequality graph, you should always start out with [SHIFT] [F5] (Cls) [EXE] to clear the display.

[SHIFT] [SETUP] [F4] (INEQ)

[EXIT]

```
▶GRAPH TYPE  : INEQ
 DRAW TYPE   : CONNECT
```


When you press the [Graph] key in the INEQ Mode, the display shown here appears.

```
Y>  Y<  Y≥  Y≤
F1  F2  F3  F4
```

Use the function keys to input the inequality you are graphing.

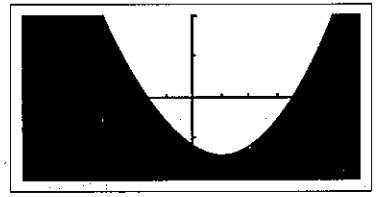
Function Key	Inputs
[F1]	Y>
[F2]	Y<
[F3]	Y≧
[F4]	Y≦

• To graph an inequality

Example **To graph $y < x^2 - 2x - 6$ using the following range parameters:**

```
Range
Xmin  : -6
 max  : 6
 scale: 1
Ymin  : -10
 max  : 10
 scale: 5
[INIT] [TRIG]
```

[SHIFT] [F5] (Cls) [EXE]
[Graph] [F2] (Y<) [X,θ,T] [x^2] [−]
[2] [X,θ,T] [−] [6] [EXE]



■Overdrawing Inequality Graphs

If you draw two or more inequality function graphs on the same screen, the area containing values that satisfy both functions is filled in.

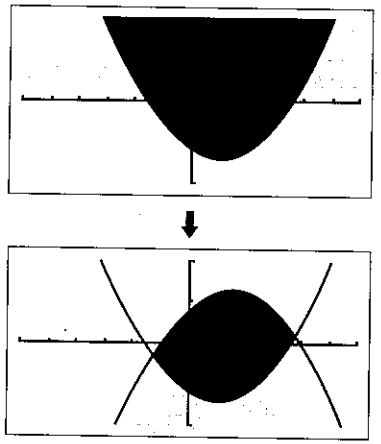
In the following input sequence we will input two functions with a single operation. Note the [SHIFT] [↵] operation that separates the two functions.

• To overdraw inequality graphs

Example To graph $y>x^2-2x-6$ and overdraw it with $y<-x^2+3x+4$ using the following range parameters:

```
Range
Xmin  : -6
 max  : 6
 scale: 1
Ymin  : -10
 max  : 10
 scale: 5
[INIT][TRIG]
```

[SHIFT][F5](Cls)[EXE]
[Graph][F1](Y>)[X,θ,T][x²][−]
[2][X,θ,T][−][6][SHIFT][↵]
[F2](Y<)[(−)][X,θ,T][x²][+]
[3][X,θ,T][+][4][EXE]



■Specifying the Value Range

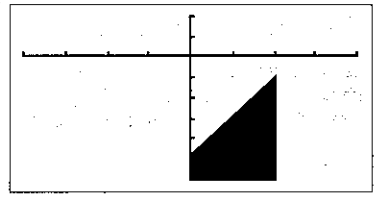
When drawing inequality graphs, you can specify the maximum and minimum values to be applied. Use the following format.

[Graph] **[Fn](inequality)** [SHIFT][,][ALPHA][[] **Xmin** [SHIFT][,] **Xmax** [ALPHA][]] [EXE]
(n=.1 to 4)

Example To graph $y\leqq 2x-5$ using the range $0\leqq x\leqq 2$, and the following range parameters:

```
Range
Xmin  : -4
 max  : 4
 scale: 1
Ymin  : -6
 max  : 2
 scale: 1
[INIT][TRIG]
```


[SHIFT][F5](Cls)[EXE]
[Graph][F4](Y≤)[2][X,θ,T]
[−][5][SHIFT][,][ALPHA][[]
[0][SHIFT][,][2][ALPHA][1]
[EXE]



8-6 Integration Graphs

To draw integration graphs, you press [SHIFT][∫dx], enter the function, and then press [EXE]. The unit produces the graph on the display with the solution range painted in.

Important

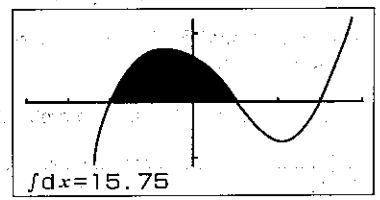
- Whenever drawing a new integration graph, you should always start out with [SHIFT][F5](Cls)[EXE] to clear the display.
- Do not try to use the BASE, EQUA, GRAPH, DYNA or TABLE Mode for integration graphing.

• To graph an integral

Example To graph $\int_{-2}^{1}(x+2)(x-1)(x-3)\,dx$ using the following range parameters:

```
Range
Xmin  : -4
 max  : 4
 scale: 1
Ymin  : -8
 max  : 12
 scale: 5
[INIT][TRIG]
```

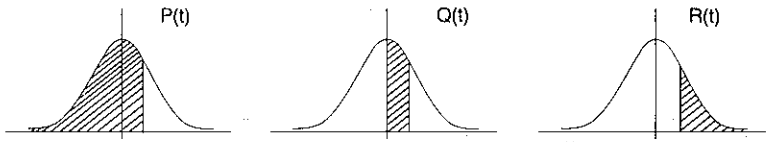
[SHIFT][F5](Cls)[EXE]
[SHIFT][∫dx][(][X,θ,T][+][2][)][(][X,θ,T]
[−][1][)][(][X,θ,T][−][3][)]
[SHIFT][,][(−)][2][SHIFT][,][1][SHIFT][,]
[5][EXE]



Note that you can also include the integration graph operation within programs.

8-7 Probability Distribution Graphs

The unit calculates the three types of probability normal distribution shown below, along with normalized variate t(x). It also produces a probability density function graph (standard normal distribution curve) for the normal distribution.



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

t(x)

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

Once you input a value that represents the normalized variate t(x) for one of the probabilities P(t), Q(t) and R(t), the unit produces the corresponding standard normal distribution curve. At this time, the probability calculation result appears on the display, with the calculation range highlighted in the graph.
To draw probability distribution graphs, the unit should be in the SD Mode and RECT Mode.

•Note that you do not need to specify range parameters with probability distribution graphs.

[SHIFT] [SETUP] [F1](RECT)

▶GRAPH TYPE : RECT DRAW TYPE : CONNECT

[EXIT]

Perform the following graph clear operation.

[SHIFT] [F5](Cls)[EXE]

•Be sure to perform the above graph clear operation before proceeding.

When you press the [F6](PQR) key, the display shown here appears.

P(Q(R(t(
[F1] [F2] [F3] [F4]

Use the function keys to input the probability distribution you are graphing.

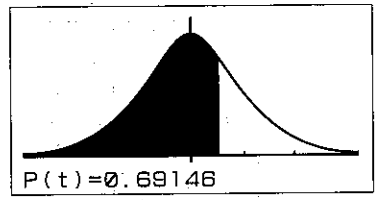
[F1](P( )..... Draws standard normal distribution curve and calculates probability P(t)
[F2](Q( )..... Draws standard normal distribution curve and calculates probability Q(t)
[F3](R( )..... Draws standard normal distribution curve and calculates probability R(t)
[F4](t( )..... Calculates normalized variate t(x)

•You cannot draw a graph for the normalized variate function t(x).

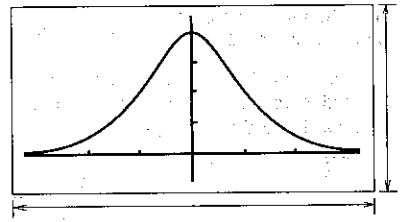
• To graph a probability distribution

Example **To graph P(0.5)**

[SHIFT] [F5](Cls)[EXE]
[Graph] [F6](PQR)[F1](P( )[0][•][5]
[)][EXE]



*The following shows the parameters that the unit uses for the probability distribution graph.



8-8 Single-Variable Statistical Graphs

To draw single-variable statistical graphs, you must use the SD Mode and the statistical graph DRAW Mode. The unit lets you draw bar graphs, line graphs and normal distribution curves using data you input.

[SHIFT] [SETUP]
[▼][▼][▼]
[F1](DRAW)

▶STAT GRAPH : DRAW

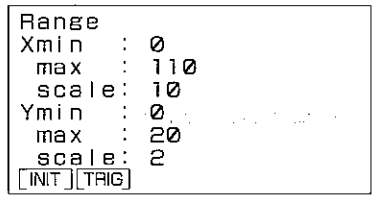
[EXIT]

• To draw a bar graph

Example **To draw a bar graph of the following data:**

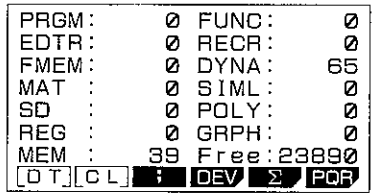
Rank	Value	Frequency
1	0	1
2	10	3
3	20	2
4	30	2
5	40	3
6	50	5
7	60	6
8	70	8
9	80	15
10	90	9
11	100	2

First, specify the range parameters. Since the maximum data value for x is 100, we will set Xmax as 110. The maximum data value for y is 15, so set Ymax as 20.



Next, specify the number of bars by increasing the number of value memories. Since we have 11 ranks, we should increase the number of memories by 11. If you skip this step, an error occurs when you try to draw the graph.

SHIFT Defm 1 1 EXE



Now clear the statistical memory.

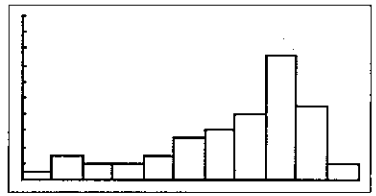
SHIFT CLR F2 (Scl) EXE

Input the data. For full details on the techniques you can use to input statistical data, see page 91.

0 F1 (DT) **10** F1 (DT) F1 (DT) F1 (DT) **20** F1 (DT) F1 (DT)
30 F1 (DT) F1 (DT) **40** F1 (DT) F1 (DT) F1 (DT)
50 F3 (;) **5** F1 (DT) **60** F3 (;) **6** F1 (DT) **70** F3 (;) **8** F1 (DT)
80 F3 (;) **15** F3 (DT) **90** F3 (;) **9** F1 (DT) **100** F1 (DT) F1 (DT)

Now draw the graph.

Graph EXE

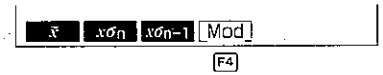


• To find the mode (Mod) on a graph

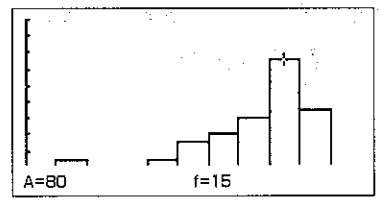
You can find the mode (Mod) on a bar graph using the pointer. Note, however that you can only perform this operation immediately after a bar graph is drawn on the display. To find the mode immediately after drawing the above bar graph.

G↔T

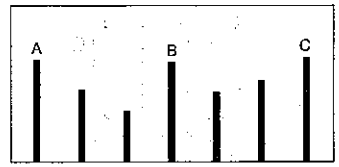
F4 (DEV)



F4 (Mod)



- The mode is indicated by the pointer flashing at the highest point on the graph. The values at the bottom of the graph show the data item [X] along with is frequency [f].
- In the case of multimodal distribution, the pointer will be located at the top of the bar that is farthest to the right. In the following graph, bars A, B, and C have the same frequency, so the pointer is located at the top of C because it is farthest to the right.



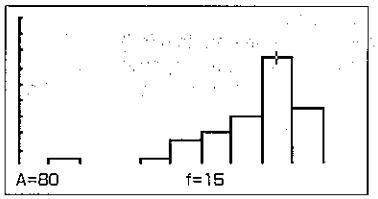
Use the following procedure to find the mode when using the STO Mode in the statistical data (STAT DATA) Mode.

G↔T

F4 (DEV)

F4 (▽)

[F1](Mod)

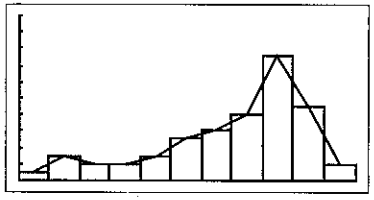


•See page 96 for information on determining Med, Max, and Min.

• To superimpose a line graph on a bar graph

While a bar graph is displayed, perform the following key operation.

[Graph][SHIFT][F4](Line)[EXE]



• To draw a normal distribution curve

Example **Using the data input above, with the following range parameters:**

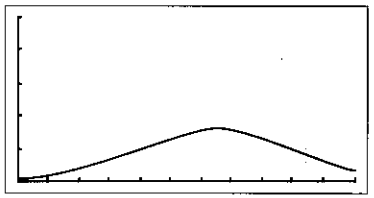
```
Range
Xmin  : 0
 max  : 110
 scale: 10
Ymin  : 0
 max  : 0.05
 scale: 0.01
[INIT][TRIG]
```

This change in range parameters is necessary because the y values are so much smaller than the x values.

Draw the graph.

[Graph][SHIFT][F4](Line)[1][EXE]

Inputting the number 1 causes a normal distribution curve to be drawn.



Notes

- Be sure to expand the number of value memories to match the number of bars in a bar graph.
- If you change the number of value memories while you are inputting data, you will not be able to draw a graph correctly.
- If you input a value that is outside the minimum and maximum ranges you specify for the range parameters, the data is stored in statistical memory but not in graph memory.
- If you input data that is greater than the maximum you specify for the y-axis, the bar is drawn to the upper limit of the display, and the points outside the range cannot be connected.
- The following is the formula the unit uses to draw the normal distribution curve.

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

- For range parameter settings, Xmin must be less than Xmax.
- The message "done" appears on the display to indicate that drawing of a bar or line graph is complete.

8-9 Paired-Variable Statistical Graphs

To draw paired-variable statistical graphs, you must use the REG Mode and the statistical graph DRAW Mode. The unit draws graphs using data you input.

[SHIFT][SETUP][F1](RECT)

```
▶GRAPH TYPE  :RECT
 DRAW TYPE   :CONNECT
```

[▼][▼][▼][F1](DRAW)

```
▶STAT GRAPH  :DRAW
```

[▼]

```
▶REG MODEL   :LIN
```

```
[LIN][LOG][EXP][PWR]
```

[F1] [F2] [F3] [F4]

The following are the types of operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

[F1](LIN) ..... Linear regression line drawing (LIN Mode)
[F2](LOG) ..... Logarithmic regression curve drawing (LOG Mode)
[F3](EXP) ..... Exponential regression curve drawing (EXP Mode)
[F4](PWR) ..... Power regression curve drawing (PWR Mode)

• To draw a paired-variable graph

Example **To draw a graph of the following data:**

xi	*yi*
−9	−2
−5	−1
−3	2
1	3
4	5
7	8

First, specify the range parameters as shown right.

```
Range
Xmin  : -10
 max  : 10
 scale: 2
Ymin  : -5
 max  : 15
 scale: 5
[INIT][TRIG]
```

Now clear the statistical memory.

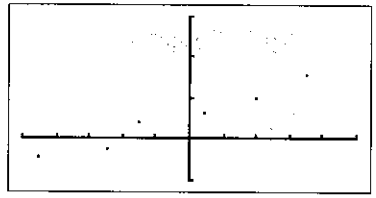
[SHIFT][CLR][F2](Scl)[EXE]

Input the data. For full details on the techniques you can use to input statistical data, see page 98.

[EXIT]

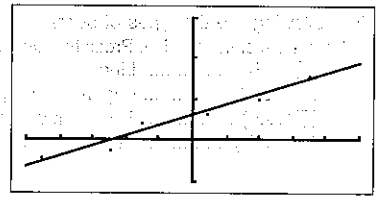
```
[DT][CL][ , ][DEV][Σ][REG]
 F1          F3
```

(↔)[9][F3](,)(↔)[2][F1](DT)
(↔)[5][F3](,)(↔)[1][F1](DT)
(↔)[3][F3](,)[2][F1](DT)
[1][F3](,)[3][F1](DT)
[4][F3](,)[5][F1](DT)
[7][F3](,)[8][F1](DT)



Now draw the graph.

[Graph][SHIFT][F4](Line)[1][EXE]



Notes

- A point is not plotted if a set of data is outside the range parameter values you specify.
- The following key operation causes an error (Ma ERROR) if no paired-variable statistical data is present in memory.
  [Graph][SHIFT][F4](Line)[1][EXE]
- For range parameter settings, Xmin must be less than Xmax.

8-10 Storing Functions in Memory

You can store up to 20 functions and expressions in memory for later recall, editing, or graphing. Rectangular coordinate, polar coordinate, and parametric functions, as well as inequalities can all be stored in memory. Note that the total amount of memory used for storage of functions cannot exceed 127 bytes.

■To Access the Graph Function Memory

Highlight the **GRAPH** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the GRAPH Mode.

[EXE]

```
GRAPH  FUNC : RECT
 Y1  :
 Y2  :
 Y3  :
 Y4  :
 Y5  :
[STO][RCL][TYPE][ , ][SEL][DRAW]
 F1   F2   F3   F4   F5   F6
```

Memory locations

The following are the types of operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

- [F1](STO) ..... Stores the graph function into memory
- [F2](RCL) ..... Recalls a graph function from memory
- [F3](TYPE) ..... Specifies a type for a stored graph function
- [F4](,) ..... Inputs a comma between parametric functions*
- [F5](SEL) ..... Selects whether or not a graph should be drawn
- [F6](DRAW) ..... Draws a graph for a stored function

*Appears in the function key menu only in the PARAM Mode.

■Graph Function Types

Before storing a function into memory, be sure to first use the following procedure to specify its type (rectangular coordinate, polar coordinate, parametric, inequality).

• To specify a function type

[F3](TYPE)

```
RECT POL PARM INEQ
F1   F2  F3   F4
```

The following are the function types that can be selected from the function menu at the bottom of the display. Press the function key below the type you want to specify.

[F1](RECT) ..... Rectangular coordinate
[F2](POL) ..... Polar coordinate
[F3](PARM) ..... Parametric functions
[F4](INEQ) ..... Inequality

• To store a rectangular coordinate function

Example **To store the following rectangular coordinate graph function in memory location Y2:**

$y = 2x^2 - 5$

First specify the function type as rectangular coordinate.

[F3](TYPE)[F1](RECT)

Input the function.

[2][X,θ,T][x²][−][5]

```
2X²−5_
STO RCL TYPE      SEL DRAW
F1
```

The currently specified memory location is indicated by a flashing pointer.

[F1](STO)

```
GRAPH  FUNC : RECT
▷Y1    :

2X²−5
STO    SELECT[↓][↑]   [SET]
```

Move the pointer to the memory location where you want to store the function.

[▼]

```
GRAPH  FUNC : RECT
 Y1    :
▷Y2    :
 Y3    :
 Y4    :
 Y5    :
2X²−5
STO    SELECT[↓][↑]   [SET]
                      F6
```


Store the function into memory.

[F6](SET)

```
GRAPH  FUNC : RECT
 Y1    :
▶Y2    =2X²−5
```

• To store a polar coordinate function

Example **To store the following polar coordinate graph function in memory location *r*3:**

$r = 5 \sin 3\theta$

First specify the function type as polar coordinate.

[F3](TYPE)[F2](POL)

Input the function.

[5][sin][3][X,θ,T]

```
5sin 3θ_
STO RCL TYPE      SEL DRAW
F1
```

The currently specified memory location is indicated by a flashing pointer.

[F1](STO)

```
GRAPH  FUNC : POL
▷r1    :

5sin 3θ
STO    SELECT[↓][↑]   [SET]
```

Move the pointer to the memory location where you want to store the function.

[▼][▼]

```
GRAPH  FUNC : POL
 r1    :
▶Y2    =2X²−5
▷r3    :
 r4    :
 r5    :
5sin 3θ
STO    SELECT[↓][↑]   [SET]
                      F6
```

Store the function into memory.

[F6](SET)

```
GRAPH  FUNC : POL
 r1    :
▶Y2    =2X²−5
▶r3    =5sin 3θ
```

• To store parametric functions

Example **To store the following parametric functions in memory location f4:**

$x = 3 \sin T$

$y = 3 \cos T$

First specify the function type as parametric.

F3(TYPE)F3(PARM)

Input the functions.

3 sin X,θ,T F4(,)

3 cos X,θ,T

```
3sin T,3cos T_
STO RCL TYPE , SEL DRAW
```

F1

The currently specified memory location is indicated by a flashing pointer.

F1(STO)

```
GRAPH FUNC:PARAM
▷f1  :

3sin T,3cos T
STO   SELECT[↓][↑]   SET
```

Move the pointer to the memory location where you want to store the function.

▼▼▼

```
GRAPH FUNC:PARAM
 f1  :
▶Y2  =2X²-5
▶r3  =5sin 3θ
▷f4  :
 f5  :
3sin T,3cos T
STO   SELECT[↓][↑]   SET
                      F6
```

Store the functions into memory.

F6(SET)

```
GPAPH FUNC:PARAM
 f1  :
▶Y2  =2X²-5
▶r3  =5sin 3θ
▶Xt4 =3sin T
▶Yt4 =3cos T
```


• To store an inequality

Example **To store the following inequality in graphic function memory location Y5:**

$y < x^2 - 2x - 6$

First specify the function type as inequality.

F3(TYPE)F4(INEQ)

Input the function.

X,θ,T x² − 2 X,θ,T − 6

```
X²-2X-6_
STO RCL TYPE   SEL DRAW
```

F1

The currently specified memory location is indicated by a flashing pointer.

F1(STO)

```
GRAPH FUNC:INEQ
▷Y1  :

X²-2X-6
STO   [Y>][Y<][Y≥][Y≤]
```

F3 F4 F5 F6

The following are the inequality types that can be selected from the function menu at the bottom of the display. Press the function key below the type you want to specify.

F3(Y>) ..... $y > f(x)$

F4(Y<) ..... $y < f(x)$

F5(Y≥) ..... $y \geqq f(x)$

F6(Y≤) ..... $y \leqq f(x)$

Move the pointer to the memory location where you want to store the function.

▼▼▼▼

```
GRAPH FUNC:INEQ
▶Y2  =2X²-5
▶r3  =5sin 3θ
▶Xt4 =3sin T
▶Yt4 =3cos T
▷Y5  :
X²-2X-6
STO   [Y>][Y<][Y≥][Y≤]
                   F4
```

Store the function into memory.

F4(Y<)

```
GRAPH FUNC:INEQ
▶Y2  =2X²-5
▶r3  =5sin 3θ
▶Xt4 =3sin T
▶Yt4 =3cos T
▶Y5  <X²-2X-6
```


A313043-2

■Editing Graph Functions in Memory

Use the following procedures to modify and delete functions that are stored in memory.

• To modify a function in memory

Example **To change the function in memory location Y2 ($y=2x^2-5$) to $y=2x^2-3$:**

Recall the function.

[F2](RCL)

```
GRAPH  FUNC:RECT
▷Y1    :
▶Y2    =2X²-5
▶r3    =5sin 3θ
▶Xt4   =3sin T
▶Yt4   =3cos T
      RCL SELECT[↓][↑] [SET]
                       [F6]
```

Scroll down to Y2.

[▼][F6](SET)

```
2X²-5_
STO RCL TYPE      SEL DRAW
```

Move the cursor to the location of the change and then input the new value.

[◀][3]

```
2X²-3_
STO RCL TYPE      SEL DRAW
[F1]
```

[F1](STO)

```
2X²-3
STO   SELECT[↓][↑]  [SET]
                    [F6]
```

Store the new function into memory.

[▼][F6](SET)

```
GRAPH  FUNC:RECT
 Y1    :
▶Y2    =2X²-3
```

• To delete a function from memory

Example **To delete the function in memory location Y2:**

Display the list of functions in memory.

Press [F1](STO).

[F1](STO)

```
STO   SELECT[↓][↑]  [SET]
                    [F6]
```

Scroll down to Y2.

Delete the function located at Y2.

[▼][F6](SET)

■Drawing Graphs from Memory

You can use either of the two following methods to draw graphs from memory.

- Drawing graphs from specific functions in memory
- Overlaying graphs for all the functions in memory

• To specify the overlaying method

When drawing overlaid graphs, you can set up the unit to draw them one-by-one or simultaneously. Use the following procedure to specify which method you want to use.

[SHIFT][SETUP][▼][▼][▼][▼]

```
▶SIMUL GRAPH:OFF

 ON  OFF
[F1] [F2]
```

Press [F1](ON) to specify that graphs should be drawn simultaneously. Press [F2](OFF) to specify that graphs should be drawn one-by-one, in graphic function memory location sequence.

[EXIT]

- When SIMUL GRAPH is ON, the graph range parameters that are stored with graph function are ignored when the graphs are drawn.

• To draw graphs from specific functions in memory

You can select one or more graph function for graph drawing. Simply press [F5](SEL) to display the menu for graph function selection.

[F5](SEL)

```
 SET  CAN              DRAW
[F1] [F2]             [F6]
```

[F1](SET) ..... Selects graph function for drawing
[F2](CAN) ..... Cancels drawing of graph of function
[F6](DRAW) ..... Draws graph

Example 1 **To draw a graph of the function in memory location Y2 ($y=2x^2-3$):**

Use the following range parameters.

```
Range
Xmin   : -5
 max   : 5
 scale: 1
Ymin   : -5
 max   : 5
 scale: 1
 INIT  TRIG
```

[F5](SEL)

```
GRAPH  FUNC:RECT
▷Y1    :
▶Y2    =2X²-3
▶r3    =5sin 3θ
▶Xt4   =3sin T
▶Yt4   =3cos T

 SET  CAN              DRAW
[F2]
```

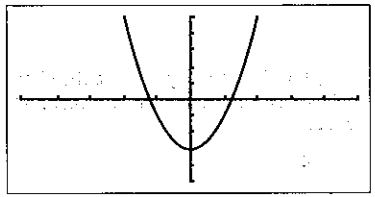
Scroll through the graphs, and cancel those that you do not want drawn. Only the functions marked with ▶ will be drawn.

▼▼[F2](CAN)
▼[F2](CAN)
▼[F2](CAN)

```
GRAPH FUNC:RECT
▶Y2  =2X²-3
 r3  =5sin 3θ
 Xt4 =3sin T
 Yt4 =3cos T
▷Y5  <X²-2X-6
[SET] [CAN]          [DRAW]
                      [F6]
```

Draw the graph.

[F6](DRAW)



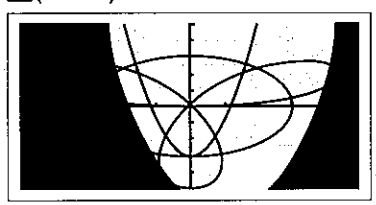
•To cancel a selection of a graph function, select that function and press [F1](SET) in place of [F2](CAN) in the above procedure.

• To overlay graphs for all the functions in memory

Example 2 **To overlay graphs for all the functions using the same range parameters as in Example 1:**

```
GRAPH FUNC:RECT
▷Y1  :
▶Y2  =2X²-3
▶r3  =5sin 3θ
▶Xt4 =3sin T
▶Yt4 =3cos T
STO RCL TYPE        SEL DRAW
                     [F6]
```

[F6](DRAW)



If you do not want the function displayed along with the graph, use the set up display to set the graph function (GRAPH FUNC) to OFF (page 23).

8-11 Graph Solve

The following types of solutions are available for graph functions drawn in the GRAPH Mode.

Roots
Maximums and minimums
y-intercepts
Intersect values for two graphs
Coordinate values at any point (value of y for x/value of x for y)
Derivative at any point

■To Display the Graph Solve Menu

[SHIFT] [G-SOLV]

```
[ROOT] [MAX] [MIN] [Y-ICPT] [ISCT] [▽]
 [F1]   [F2]  [F3]  [F4]    [F5]   [F6]
```

The following are the solutions that can be selected from the function menu at the bottom of the display. Press the function key below the solution you want to specify.

[F1](ROOT) ..... Roots
[F2](MAX) ..... Maximum
[F3](MIN) ..... Minimum
[F4](Y-ICPT) ..... y-intercept
[F5](ISCT) ..... Intersection of two graphs
[F6](▽) ..... Display of the second Graph Solve menu

Pressing [F6](▽) causes the following menu to appear on the display.

[F6](▽)

```
[Y-CAL] [X-CAL] [d/dx]
 [F1]    [F2]    [F3]
```

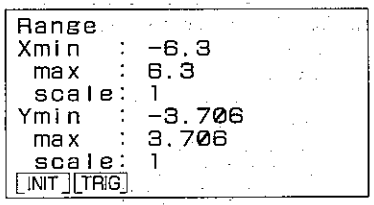
Press the function key below the operation you want to specify.

[F1](Y-CAL) ..... y-coordinate value for a given x-coordinate
[F2](X-CAL) ..... x-coordinate value for a given y-coordinate
[F3](d/dx) ..... Derivative for a given point

Except for the intersection of two graphs, all of the following operations are performed after drawing of the following function graphs.

Memory Area Y1: $y = x + 1$
Memory Area Y2: $y = x\,(x + 2)\,(x - 2)$

The range parameter settings shown here are also used.

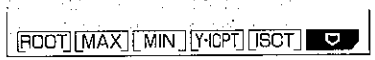


•For details on drawing graphs, see section "8-10 Storing Functions in Memory" starting on page 169.

■To Determine Roots

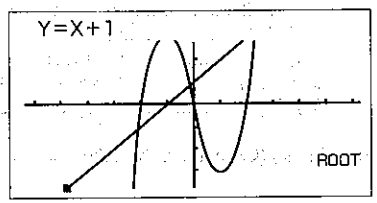
Example **To determine the roots for $y = x(x + 2)(x - 2)$:**

SHIFT G-SOLV



F1

F1(ROOT)
(This puts the unit into standby waiting for selection of a graph.)

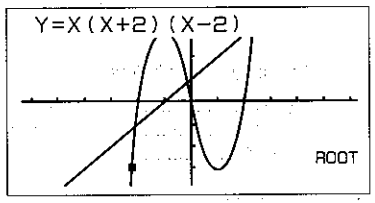


•A "■" cursor appears on the graph that has the lowest memory area number.

Specify the graph you want to use.

▼

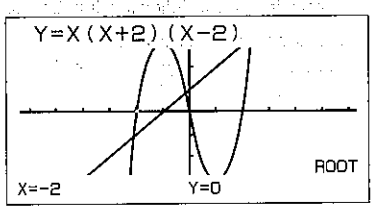
•Use ▲ and ▼ to move the cursor to the graph whose roots you want to find.



Determine the root.

EXE

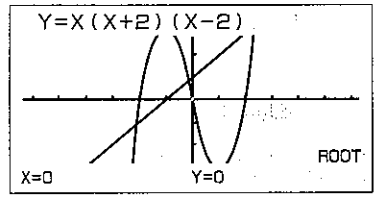
•Roots are found starting from the left.



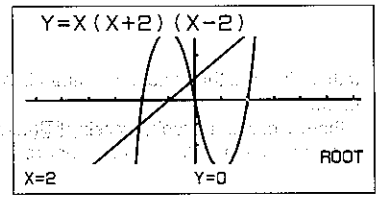
Search for the next root to the right.

▶

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



▶

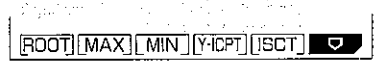


•You can use ◀ to move back to the left.
•If there is only one graph, pressing F1(ROOT) directly displays the root (selection of the graph is not required).

■To Determine Maximums and Minimums

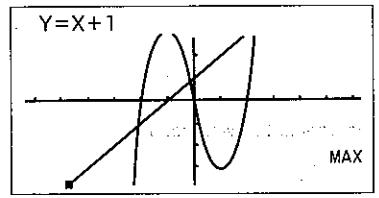
Example **To determine the maximum and minimum for $y = x(x + 2)(x - 2)$:**

SHIFT G-SOLV



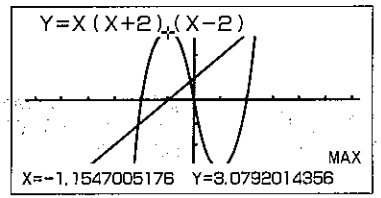
F2

F2(MAX)
(This puts the unit into standby waiting for selection of a graph.)



Specify the graph and determine the maximum.

▼EXE

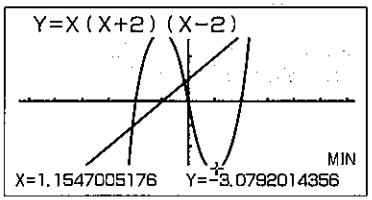


SHIFT G-SOLV

F3(MIN)

Specify the graph and determine the minimum.

▼ EXE

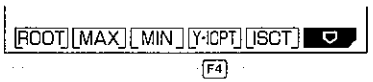


- If there is more than one maximum/minimum, you can use ◀ and ▶ to move between them.
- If there is only one graph, pressing F2(MAX)/F3(MIN) directly displays the maximum/minimum (selection of the graph is not required).

■To Determine *y*-intercepts

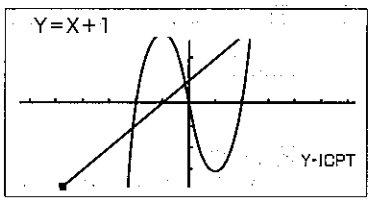
Example **To determine the *y*-intercept for $y = x + 1$:**

SHIFT G-SOLV



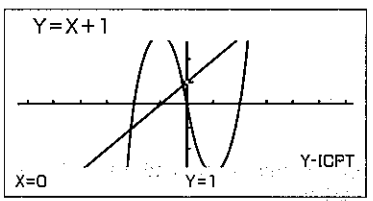
F4(Y-ICPT)

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



Determine the *y*-intercept.

EXE

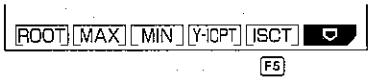


- *y*-intercepts are the points that the graph intersects the *y*-axis.
- If there is only one graph, pressing F4(Y-ICPT) directly displays the *y*-intercepts (selection of the graph is not required).

■To Determine Points of Intersection for Two Graphs

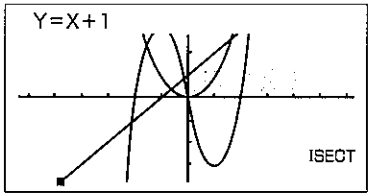
Example **After drawing the following three graphs, determine the points of intersection for the Graph A and Graph C. Use the same range parameters as those defined for the examples above:**
Graph A: $y = x + 1$
Graph B: $y = x(x + 2)(x - 2)$
Graph C: $y = x^2$

SHIFT G-SOLV



F5(ISCT)

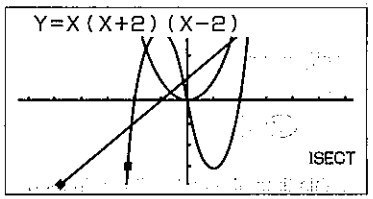
(This puts the unit into standby waiting for selection of a graph.)



Specify Graph A.

EXE

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



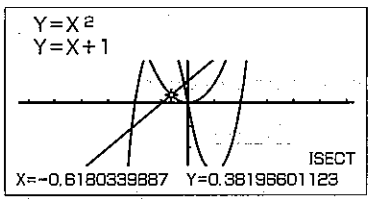
Specify the second graph (Graph C, here) to determine the points of intersection.

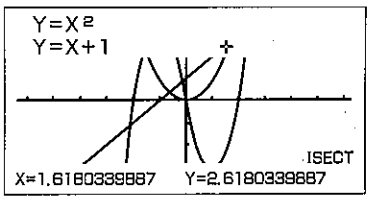
▼ EXE

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

▶

- The next intersection to the right is found. If there is no intersection to the right, nothing happens when you perform this operation.



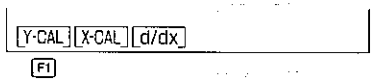


•You can use ◀ to move back to the left.
•If there are only two graphs, pressing F5(ISCT) directly displays the intersections (selection of the graph is not required).

■To Determine a Coordinate (x for a given y/y for a given x)

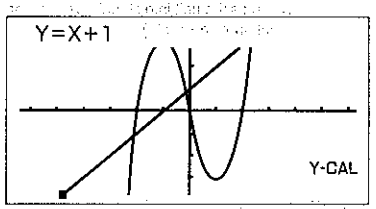
Example **To determine the y-coordinate for x – 0.5 and the x-coordinate for y = 1.8 in the graph $y = x\,(x + 2)\,(x - 2)$:**

SHIFT G-SOLV F6(▽)



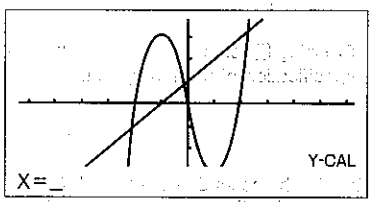
F1

F1(Y-CAL)



Specify a graph.

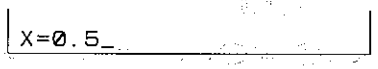
▼ EXE



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

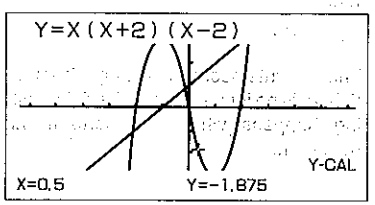
Input the x-coordinate value.

0 • 5

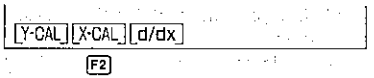


Determine the corresponding y-coordinate value.

EXE

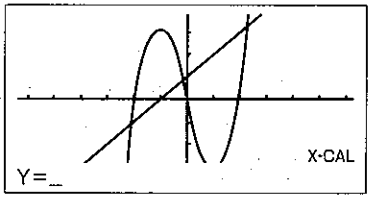


SHIFT G-SOLV F6(▽)



F2

F2(X-CAL)



Specify a graph.

▼ EXE

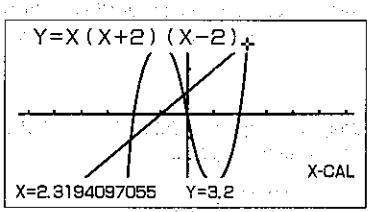
•At this time, the unit waits for input of a y-coordinate value.

Input the y-coordinate value.

3 • 2

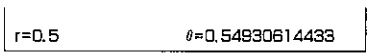
Determine the corresponding x-coordinate value.

EXE

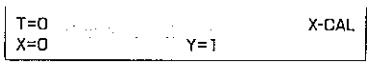


•If there is more than one x-coordinate value for a given y-coordinate value or more than one y-coordinate value for a given x-coordinate value, use ▶ and ◀ to move between them.
•The display used for the coordinate values depends on the graph type as shown below.

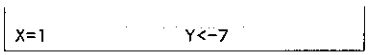
•Polar Coordinate Graph



•Parametric Graph



•Inequality Graph

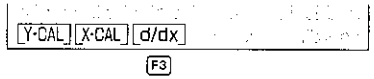


•Note that you can not determine a *y*-coordinate for a given *x*-coordinate with a parametric graph.
•If there is only one graph, pressing [F1](Y-CAL)/[F2](X-CAL) directly displays the *x*-coordinate/*y*-coordinate (selection of the graph is not required).

■To Determine the Derivative for a Given Point

Example **To determine the derivative at the origin (*x*, *y*) = (0, 0) for the graph *y* = *x* (*x* + 2) (*x* − 2):**

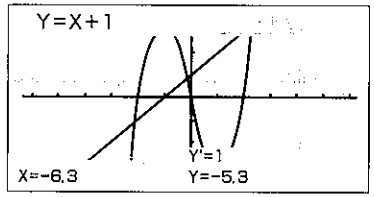
[SHIFT][G⇔X][F6](▽)



Calculate the coordinate value and derivative.

[F3](*d*/*dx*)

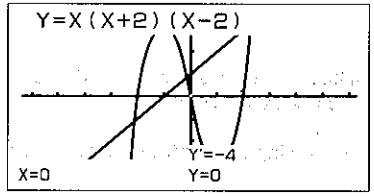
•The coordinate for the leftmost point on the display and the derivative appears on the display for graph whose function is stored in the lowest numbered memory area.



Specify a graph and determine the derivative for another point.

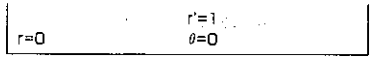
(▼)(▶) ~ (▶)

•Pressing (▶) and (◀) moves the pointer.

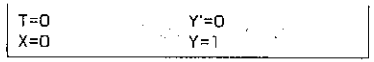


•The display used for the coordinate values depends on the graph type as shown below.

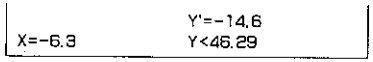
•Polar Coordinate Graph



•Parametric Graph



•Inequality Graph



Important

•Depending on the range parameter settings, there may be some error in solutions produced by Graph Solve.
•If no solution can be found for any of the above operations, the message "No solution" appears on the display.
•The following conditions may interfere with precision and make it impossible for the unit to produce a result.
When the solution is located at a point that is tangential to the *x*-axis
When the solution is located at a point that is tangential to the two graphs

8-12 Other Graph Functions

The functions described in this section can be used with rectangular coordinate, polar coordinate, parametric, inequality, and statistical graphs.

Important

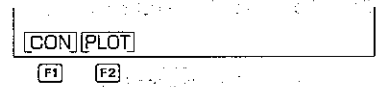
The procedures described here can be performed in the COMP, SD, REG, MAT, or TABLE Mode or in the GRAPH Mode. The following examples show operation for the COMP Mode only.

■Setting the Type of Graphing Method

There are two types of graphing methods that you can choose between: *connection* (CONNECT) and *plotting* (PLOT).
With the connection method, points that are plotted are connected by lines. With the plotting method, only the points are plotted, without connection.

• To specify the drawing method

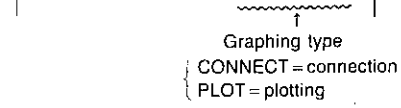
[SHIFT][SET UP](▼)



Press [F1](CON) to select connection or [F2](PLOT) to select plotting.

[F1](CON)

[EXIT]



■Trace Function

The Trace Function lets you move a pointer along the line in a graph and display coordinate values at any point. The following illustrations show how values are displayed for each type of graph.

•Rectangular Coordinate Graph

X=0.63492063492 Y=−1.2889896699

•Polar Coordinate Graph

r=0.77659173134 θ=1.0367255756

•Parametric Graph

T=1.4835298641
X=−0.3134070272 Y=8.7473845529

•Inequality Graph

X=1.4285714285 Y<−6.8163265306

• To determine the values of points of intersection

Example **To determine the values of the points of intersection for the following equations:**

$y = x^2 - 3$

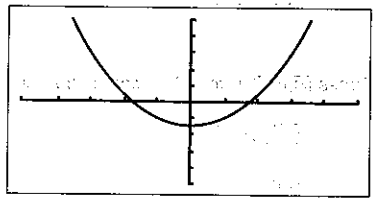
$y = -x + 2$

Use the following range parameters:

```
Range
Xmin  : -5
 max  : 5
 scale: 1
Ymin  : -10
 max  : 10
 scale: 2
[INIT][TRIG]
```

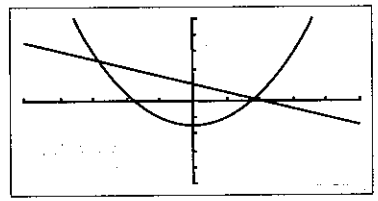
Draw the graph of the first equation.

[MENU](COMP)[EXE]
[SHIFT][SETUP][F1](RECT)[EXIT]
[SHIFT][F5](Cls)[EXE]
[Graph][X,θ,T][x²][−][3][EXE]



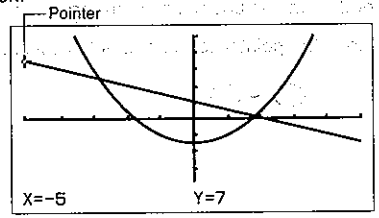
Overdraw the graph of the second equation.

[Graph][→][X,θ,T][+][2][EXE]



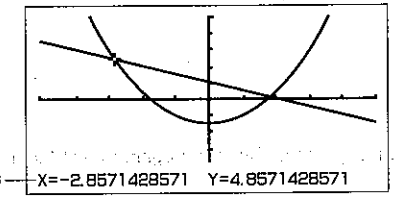
Press [F1](Trace) to activate the Trace Function.

[F1](Trace)

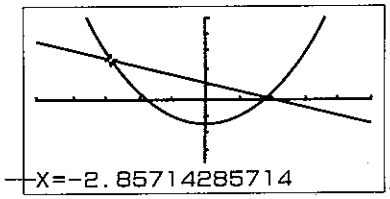


Move the pointer using ▶ and ◀. Holding down either key moves the pointer at high speed.
Move the pointer to the first intersection.
When the pointer is at the location you want, press [F6](Coord) to view coordinates individually. Each press of [F6](Coord) changes the coordinate display in the following sequence:

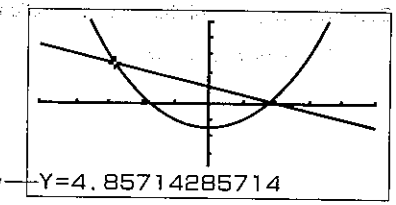
▶ ~ ▶



[F6](Coord)



[F6](Coord)

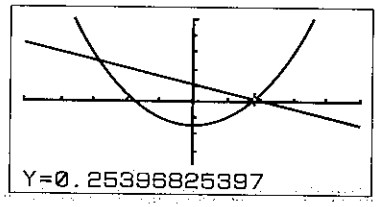


Important

The pointer does not move at fixed intervals. It follows the dots on the display. Because of this, the values provided for coordinates are approximate.

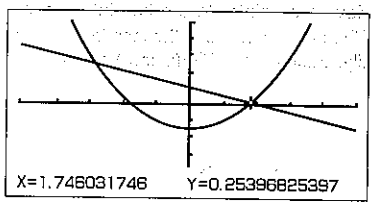
Move the pointer to the next intersection.

▶ ~ ▶



You can then use [F6](Coord) to view the x and y coordinate values.

[F6](Coord)



Finally, press [F1](Trace) again to exit the Trace Function.

• To move the trace between two graphs

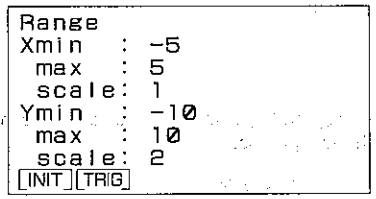
This operation can be used to trace multiple graphs on the same display. In the COMP, SD, REG, MAT or TABLE Mode this operation can be used with up to six graphs that are layered using multi-statements or programming. In the GRAPH Mode, all graphs that are drawn on the display can be traced.

Example **To trace points on the following equations (using a multistatement):**

$y=(x+2)(x-3)$

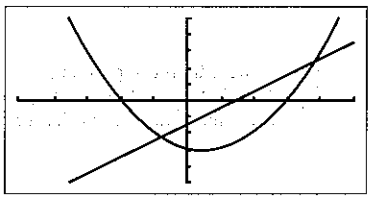
$y=2x-3$

Use the following range parameters:



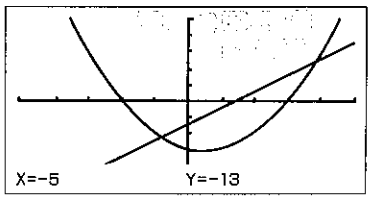
Execute the multistatement that draws the two graphs.

[SHIFT] [SETUP] [F1](RECT) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[Graph] ([X,θ,T] [+] 2) ([X,θ,T] [−] 3)
[SHIFT] [PRGM] [F6](:)
[Graph] 2 [X,θ,T] [−] 3 [EXE]



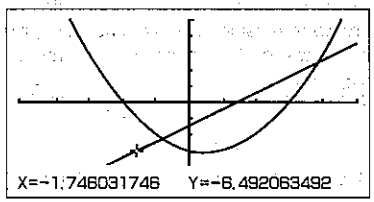
Press [F1](Trace) to activate the Trace Function. The coordinate values on the display are for x = X Min of the graph drawn by the last function in the multistatement ($y = 2x - 3$ in this example). The pointer is also located on the last graph.

[F1](Trace)



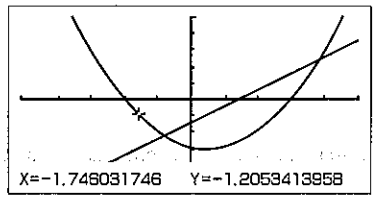
Move the pointer along the line where it is located using ▶ and ◀. Holding down either key moves the pointer at high speed.

▶ ~ ▶



Use ▲ and ▼ to move the pointer between the two graphs.

▲(or ▼)



Note

- If you have more than two graphs shown on the display, the ▲ and ▼ cursors can be used to move the pointer from graph to graph.
  When you are finished, press [F1](Trace) again to exit the Trace Function.

■Scrolling Graphs

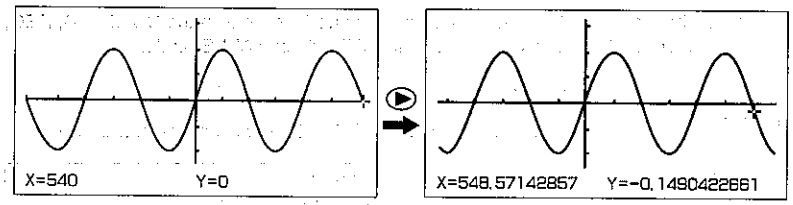
If the graph you are tracing runs off the display to the left or right, the display scrolls automatically to follow the Trace Function pointer as you trace the graph.

Example

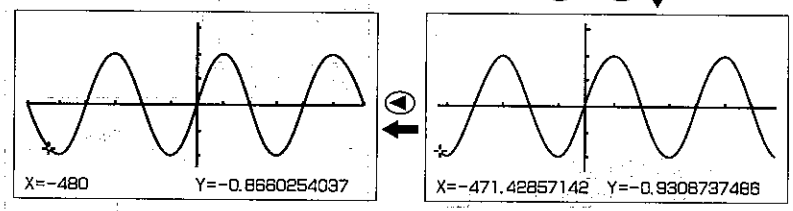
[SHIFT] [DRG] [F1](Deg)[EXE]
[Graph] [sin] [EXE]

[F1](Trace)

▶ ~ ▶



◀ ~ ◀



- You cannot scroll polar coordinate or parametric graphs. You also cannot scroll overdrawn graphs that contain polar coordinate or parametric graphs.
- If DUAL GRAPH is switched on when you activate the trace function, you will not be able to scroll the display (page 23).

■Notes on Using the Trace Function

- You can use the Trace Function immediately after you draw a graph only. If you draw a graph and then perform a calculation or any other operation (besides [M]-Disp, Range, or G-T), the Trace Function will be unavailable.
- The values for the x- and y-coordinates at the bottom of the display use 12-digit or 7-digit mantissas with a 2-digit exponent.
- You cannot use the Trace Function during program execution.
- Once program execution is suspended by a "◢" symbol, you can use the Trace Function on a graph produced at that point.
- If a display statement (◢) caused the first graph to be drawn (indicated when the message "— Disp —" is shown on the display), drawing the subsequent graph after activating the trace function causes the previous coordinates ("x =" and "y =") to be cleared from the display.

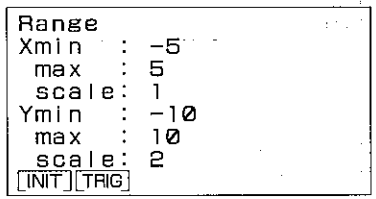
■Plot Function

The Plot Function makes it possible to plot points anywhere on a graph.

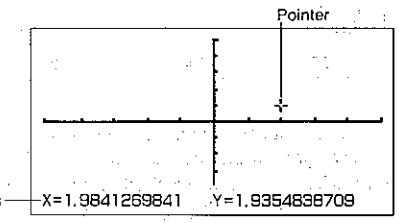
Note that there are two different plot operations: one for graphs in the COMP, SD, REG, or MAT Mode, and another for graphs in the GRAPH or TABLE Mode.

• To plot points in the COMP, SD, REG or MAT Mode

Example **To plot a point at $x=2$, $y=2$, with the following range parameters:**

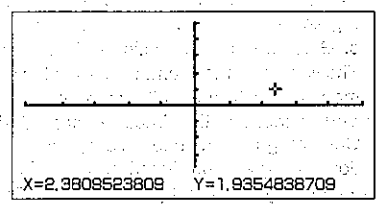


SHIFT F5 (Cls) EXE
SHIFT F3 (Plot) 2 SHIFT , 2 EXE

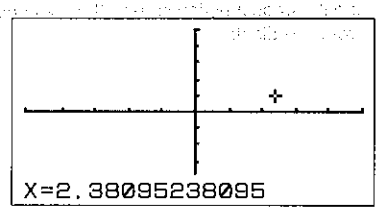


Move the pointer using ▶, ◀, ▲ and ▼. Holding down these keys moves the pointer at high speed.

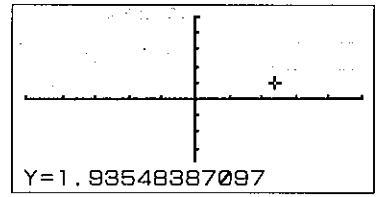
▶▶▶▶▶



F6 (Coord)

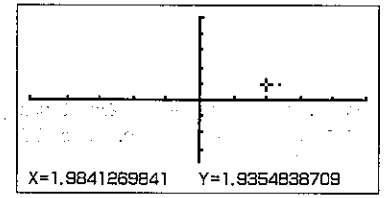


F6 (Coord)



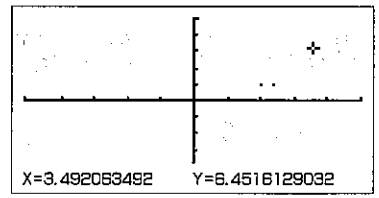
When the pointer is at the location you want, press EXE to plot a point. At this time, the pointer returns to the original point you specified (2, 2 in this example).

EXE



You can change the original point at any time by pressing F3 (Plot) and inputting new coordinates.

F3 (Plot) 3 • 5 SHIFT , 6 • 5 EXE

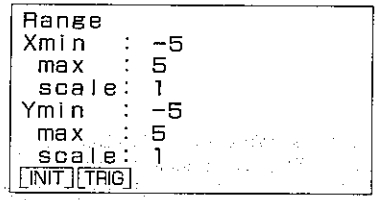


Notes

- If you activate the Plot Function without specifying an x-coordinate and y-coordinate, the pointer appears in the center of the screen.
- If you specify a point that is outside the range set up by the range parameters, the pointer does not appear on the display.
- The x-coordinate value of the current pointer location is stored in the **X** value memory. The y-coordinate value is stored in the **Y** value memory.

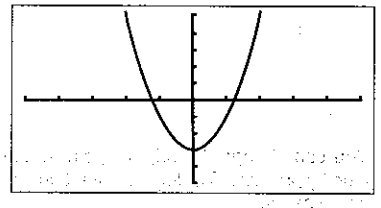
• To plot points in the GRAPH or TABLE Mode

Example **To plot a point on the graph represented by $y = 2x^2 - 3$, with the following range parameters:**



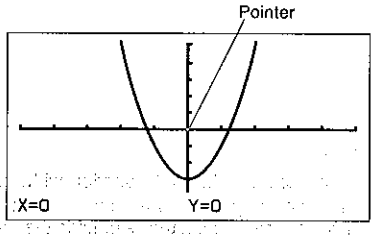
First draw the graph for $y = 2x^2 - 3$ using the procedures described on page 175.

F6(DRAW)

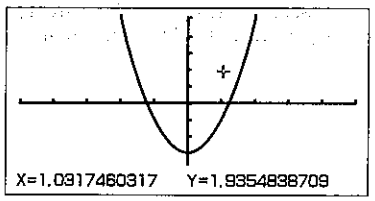


Activate the Plot Function, and the pointer appears flashing in the center of the display.

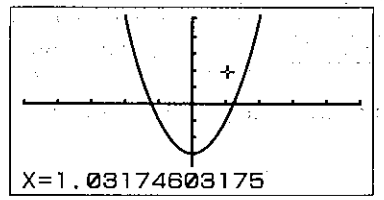
F3(Plot)



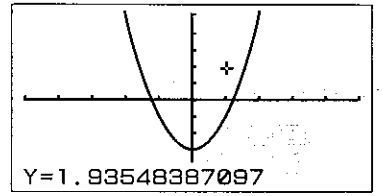
Use the cursor keys to move the pointer around the display.



F6(Coord)

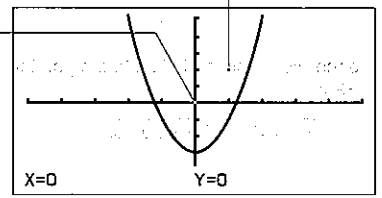


F6(Coord)



When the pointer is at the location you want, press EXE to plot a point.

You can return the pointer to the center of the display at any time by pressing F3(Plot).



Notes

- You can switch the Plot Function off by pressing F5(Cls). When you do, the graph is cleared from the display and then redrawn, without the points that you plotted.
- Whenever you are using the Plot Function, the location of the pointer is maintained in value memory. The x-coordinate is stored in value memory X, while the y-coordinate is stored in value memory Y.

■Line Function

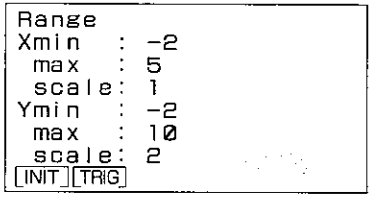
With the Line Function, you can link two points with a straight line.

Note that there are two different line operations: one for graphs in the COMP, SD, REG, or MAT Mode, and another for graphs in the GRAPH or TABLE Mode.

• To draw a line in the COMP, SD, REG or MAT Mode

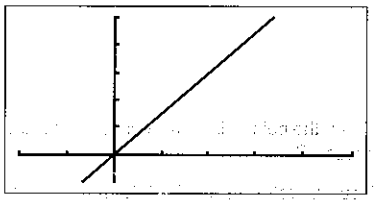
Example **To draw the graph for $y = 3x$, and then draw a line from the point on the graph where $x = 2$ and $y = 6$:**

Use the following range parameters:



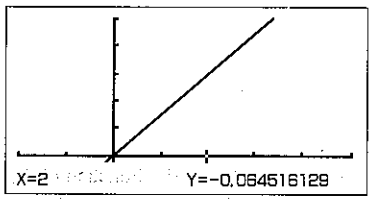
Draw the graph.

SHIFT F5 (Cls) EXE
Graph 3 X,θ,T EXE



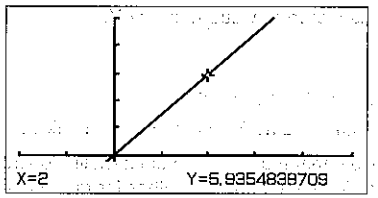
Use the Plot Function to locate the pointer at $x = 2$, $y = 0$.

F3 (Plot) 2 SHIFT , 0 EXE



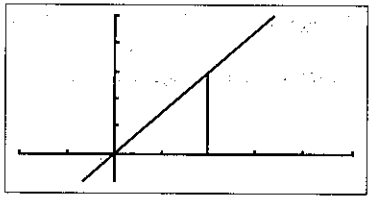
Move the pointer up to the graph line.

F3 (Plot) 2 SHIFT , 0 EXE
▲ ~ ▲



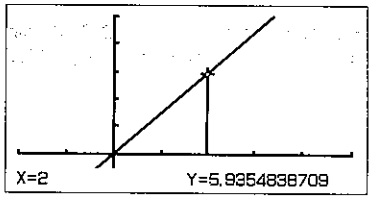
Draw the line.

F4 (Line) EXE



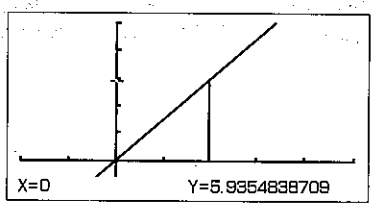
Now draw another line to the y-axis. Since the x- and y-coordinates of the point you last plotted are stored in **X** and **Y** value memories, you can easily move the pointer back to the point on the graph. Note the following operation.

F3 (Plot) ALPHA X SHIFT , ALPHA Y
EXE



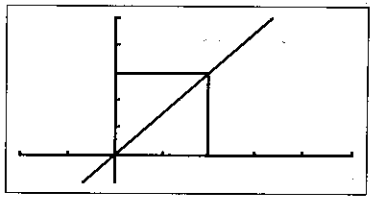
Move the pointer to the y-axis.

◀ ~ ◀



Draw the line.

F4 (Line) EXE



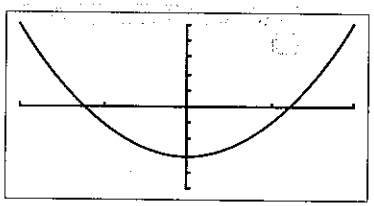
• To draw lines in the GRAPH or TABLE Mode

Example **To draw the graph for $y=2x^2-3$ and then draw a line from the minimum point on the graph to the point where $x=2$ and $y=5$:**

Use the following range parameters:

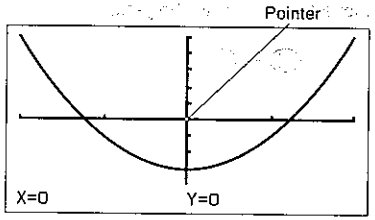
```
Range
Xmin  : -2
 max  : 2
 scale: 1
Ymin  : -5
 max  : 5
 scale: 1
[INIT] [TRIG]
```

First draw the graph for $y=2x^2-3$ using the procedures described on page 175.



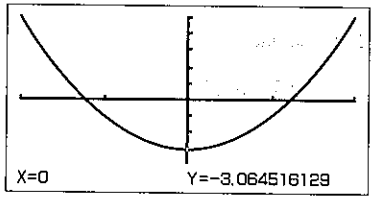
Activate the Plot Function, and the pointer appears flashing in the center of the display.

[F3](Plot)



Use the cursor keys to move the pointer to the minimum point on the graph, and press [EXE].

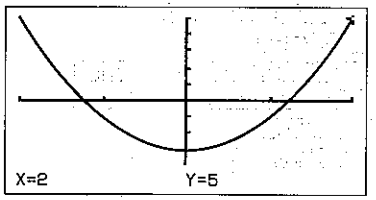
▼ ~ ▼ [EXE]



Use the cursor keys to move the pointer to the point where $x=2$ and $y=5$.

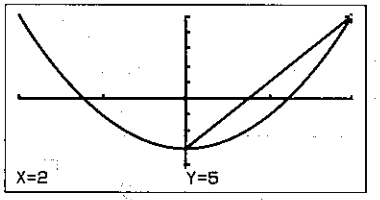
▶ ~ ▶

▲ ~ ▲



Press [F4](Line) to connect the two points with a line.

[F4](Line)



Note

•You can switch the Line Function off by pressing [F5](Cls). When you do, the graph is cleared from the display and then redrawn, without the lines you drew.

■Graph Scroll Function

Immediately after you have drawn a graph, you can scroll it on the display. Use the cursor keys to scroll the graph left, right, up and down. The display is scrolled in increments of 12 dots, with the display being redrawn after each scroll operation.

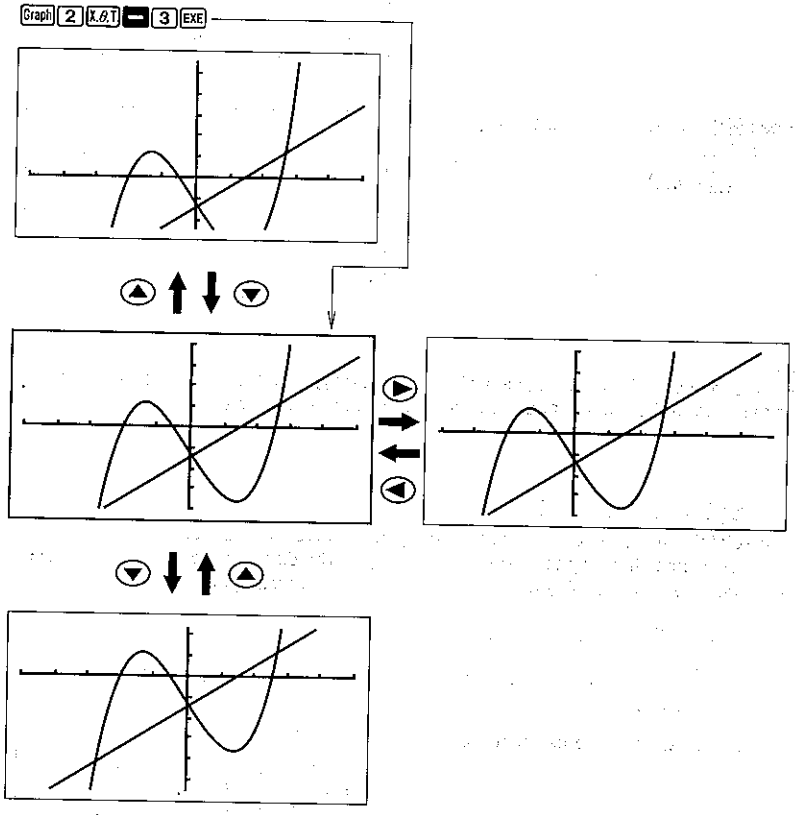
• To scroll the graph on the display

Example **To draw the graph for $y=0.25(x+2)(2x+1)(2x-5)$, $y=2x-3$, and then scroll it:**

Use the following range parameters:

```
Range
Xmin  : -5
 max  : 5
 scale: 1
Ymin  : -8
 max  : 8
 scale: 2
[INIT] [TRIG]
```

[SHIFT] [SET UP] [F1] (RECT) [EXIT]
[SHIFT] [F5] (Cls) [EXE]
[Graph] [0] [•] [2] [5] [(] [X,θ,T] [+] [2] [)]
[(] [2] [X,θ,T] [+] [1] [)] [(] [2] [X,θ,T] [−]
[5] [)] [SHIFT] [↵]
[Graph] [2] [X,θ,T] [−] [3] [EXE]



•You cannot scroll bar graphs and line graphs produced using single-variable statistical data.

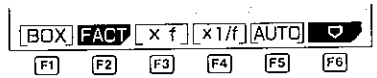
■Zoom Functions

You can use Zoom to enlarge or reduce graphs on the display.

■Before using Zoom

Immediately after drawing a graph, press [F2] (Zoom) to display the first Zoom/Auto Range menu.

[F2] (Zoom)

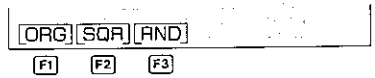


The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to specify.

- [F1] (BOX) ..... Graph enlargement using the Box Zoom function
- [F2] (FACT) ..... Specification of *x*- and *y*-axis zoom factors
- [F3] (× f) ..... Enlargement according to preset zoom factors
- [F4] ($\times {}^{1}/_{f}$) ..... Reduction according to preset zoom factors
- [F5] (AUTO) ..... Automatic setting of *y*-axis range values for drawing of graph to use full *y*-axis (page 209)
- [F6] (▽) ..... Display of the second Zoom/Auto Range menu

Pressing [F6] (▽) causes the following menu to appear on the display.

[F6] (▽)



Press the function key below the operation you want to specify.

- [F1] (ORG) ..... Returns an enlarged or reduced graph to its original size
- [F2] (SQR) ..... Adjusts ranges to make *x*-range the same as the *y*-range (page 211)
- [F3] (RND) ..... Rounds coordinate values at the current pointer location to the optimum number of significant digits (page 212)

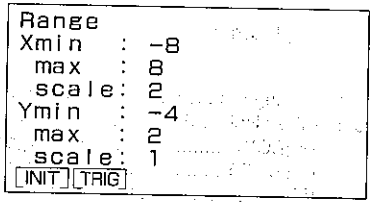
■Box Zoom Function

The Box Zoom Function lets you cut out a specific section of a graph for zooming.

• To zoom in on a part of a graph

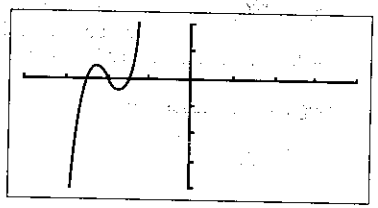
Example **To specify a box on the graph for $y=(x+5)(x+4)(x+3)$, with the following range parameters:**

Specify the range parameters.



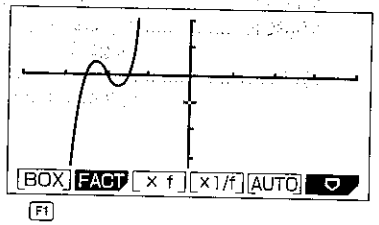
Draw the graph.

SHIFT SETUP F1(RECT) EXIT
SHIFT F5(Cls) EXE
Graph (X,θ,T + 5) (X,θ,T + 4) (X,θ,T + 3) EXE



Press F2(Zoom) and a pointer appears flashing in the center of the display.

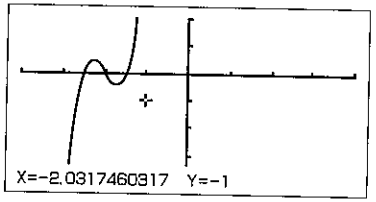
F2(Zoom)



F1

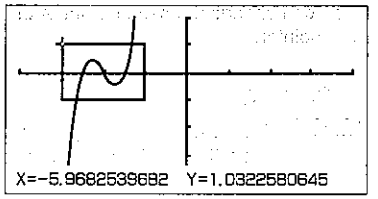
Press F1(BOX) and move the pointer using the cursor keys.
Once the pointer is located where you want one corner of the box to be, press EXE.

F1(BOX)
◀ ~ ◀ EXE



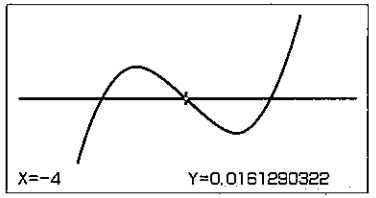
Move the pointer to the location of the corner diagonally opposite the one you have just set. Note that a box automatically appears on the display.

▲ ~ ▲◀ ~ ◀



When the pointer is located where you want the other corner of the box to be, press EXE.

EXE

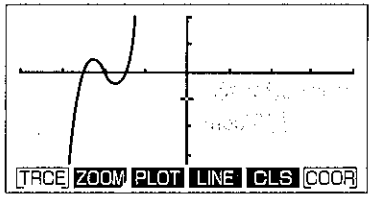


Note that the box you defined becomes the outline of the display, and the graph is enlarged to fit.
You can repeat the enlarge operation and make enlargements of part of an enlarged graph.

• To return a graph to its original size

Example **To return to the graph enlarged above to its original size:**

F2(Zoom) F6(▽)
F1(ORG)



- If you locate the second corner of the box horizontally or vertically with the first corner, no box is formed, and so the graph is not enlarged.
- For graphs drawn in the COMP, SD, REG, or MAT Mode, the Box Zoom Function can be used to zoom only the most recently drawn six graphs. In the case of the GRAPH Mode, the Box Zoom Function can be used to zoom any graphs drawn.
- You cannot enlarge or reduce a single-variable bar or line graph.

■Using the Factor Zoom Function to Enlarge and Reduce the Entire Graph

You can enlarge or reduce the entire graph. You can set different factors for the x and y-axes, which means that you can double the length while leaving the height unchanged, or vice versa.

You can change the center point of the Factor Zoom by using the cursor keys to move the pointer.

• To enlarge a graph

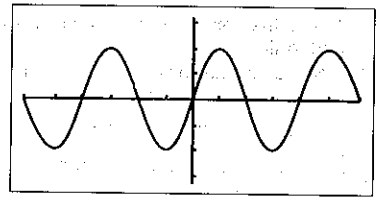
Example **To enlarge the graph for $y = \sin x$ by 1.5 times on the x-axis and 2 times on the y-axis, using the following range parameters:**

Specify the range parameters.

```
Range
Xmin  : -540
 max  : 540
 scale: 90
Ymin  : -1.6
 max  : 1.6
 scale: 0.5
[INIT] [TRIG]
```

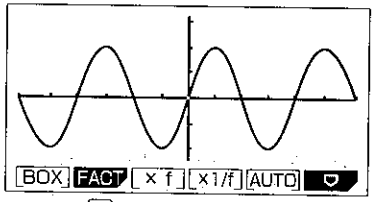
Draw the graph.

[SHIFT] [SETUP] [F1](RECT) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[SHIFT] [DRG] [F1](Deg) [EXE]
[Graph] [sin] [X,θ,T] [EXE]



Press [F2](Zoom).

[F2](Zoom)



[F2]

Press [F2](FACT) to display the Factor Input Screen.

[F2](FACT)

```
Factor
 Xfact: 2
 Yfact: 2


[INIT]
```


Input the zoom factors for the x-axis and y-axis.

[1] [•] [5] [EXE]

```
Factor
 Xfact: 1.5
 Yfact: 2
```

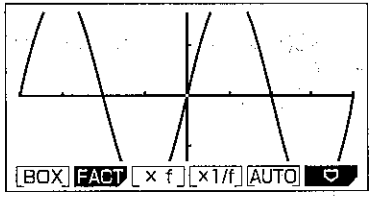
[2] [•] [0] [EXE]

```
Factor
 Xfact: 1.5
 Yfact: 2.0
```

[EXIT]

Press [F3](×f) to redraw the graph according to the factors you have specified.

[F3](×f)



At this time, the range parameters are changed as follows:

[Range]

```
Range
Xmin  : -360
 max  : 360
 scale: 90
Ymin  : -0.8
 max  : 0.8
 scale: 0.5
[INIT] [TRIG]
```

You can repeat the enlarge operation and enlarge the enlarged graph again.

• To reduce a graph

Example **To reduce the graph for $y = \sin x$ by 1.5 times on the x-axis and 2.0 times on the y-axis, using the following range parameters:**

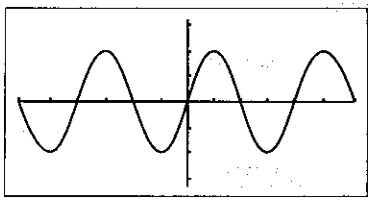
Specify the range parameters.

```
Range
Xmin  : -540
 max  : 540
 scale: 90
Ymin  : -1.6
 max  : 1.6
 scale: 0.5
[INIT] [TRIG]
```


A313043-2

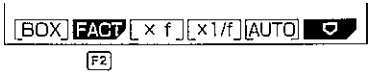
Draw the graph.

[SHIFT] [SETUP] [F1] (RECT) [EXIT]
[SHIFT] [F5] (Cls) [EXE]
[SHIFT] [DRG] [F1] (Deg) [EXE]
[Graph] [sin] [X,θ,T] [EXE]



Press [F2] (Zoom).

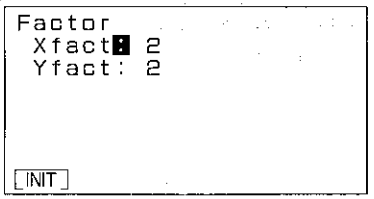
[F2] (Zoom)



[F2]

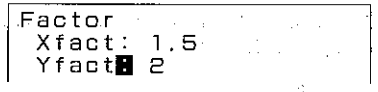
Press [F2] (FACT) to display the Factor Input Screen.

[F2] (FACT)

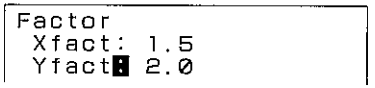


Input the zoom factors for the x-axis and y-axis.

[1] [•] [5] [EXE]



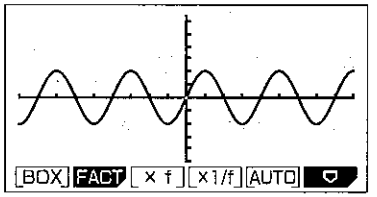
[2] [•] [0] [EXE]



[EXIT]

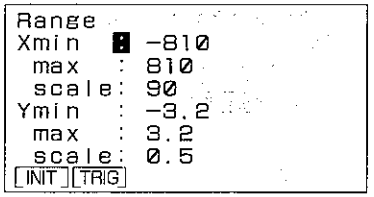
Press [F4] ($\times^1/_f$) to redraw the graph according to the factors you have specified.

[F4] ($\times^1/_f$)



At this time, the range parameters are changed as follows:

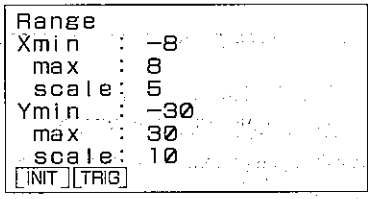
[Range]



You can repeat the reduce operation and reduce the reduced graph again.

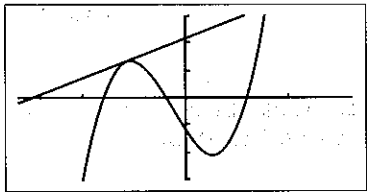
• To specify the center point of an enlarged display

Example **To enlarge the graphs: $y=(x+4)(x+1)(x-3)$, and $y=3x+22$ by 5 times on the x-axis and y-axis, with the apparent point of tangency at the center of the display. Use the following range parameters:**



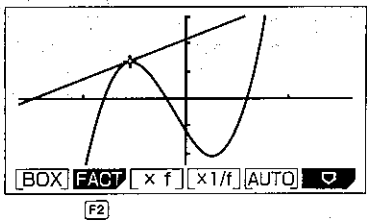
Draw the graph.

[SHIFT] [SETUP] [F1] (RECT) [EXIT]
[SHIFT] [F5] (Cls) [EXE]
[Graph] [(] [X,θ,T] [+] [4] [)] [(] [X,θ,T] [+]
[1] [)] [(] [X,θ,T] [−] [3] [)] [SHIFT] [↵]
[Graph] [3] [X,θ,T] [+] [2] [2] [EXE]



Press [F2] (Zoom) to display the Zoom Menu and the pointer appears flashing in the center of the display. Use the cursor keys to move the pointer to the point of tangency.

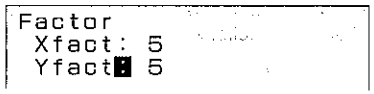
[F2] (Zoom)
[◀] ~ [◀] [▲] ~ [▲]



[F2]

Input the zoom factors for the x-axis and y-axis.

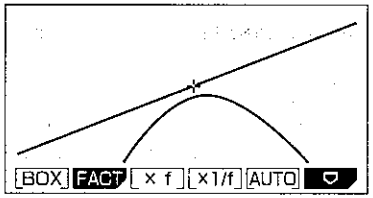
[F2](FACT)
[5][EXE][5][EXE]



[EXIT]

Press [F3](×f) to redraw the graph according to the factors you have specified.

[F3](×f)

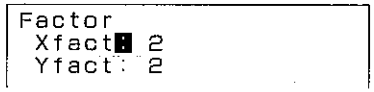


Note that these graphs are not tangent as they appear on the normal (unenlarged) display.

• To initialize the zoom factors

[F2](Zoom)[F2](FACT)[F1](INIT)

Anytime you perform the above operation, the unit initializes the zoom factors to the following settings.



• To specify the zoom factors within a program

Use the following format to specify the zoom factors in a program.

Factor (Xfact), (Yfact)

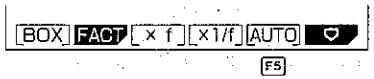
Note

- You can use only positive values as zoom factors. You can perform calculations that consist of up to 13 numbers, operators, etc.
- For graphs drawn in the COMP, SD, REG, or MAT Mode, the Factor Zoom can be used to zoom only the most recently drawn six graphs. In the case of the GRAPH Mode, Factor Zoom can be used to zoom any graphs drawn.
- You cannot enlarge or reduce a single-variable bar or line graph.

■ Auto Range

The Auto Range function automatically sets the range value of the y-axis so that the graph completely fills the screen along the y-axis. This function is available from the first Zoom/Auto Range menu.

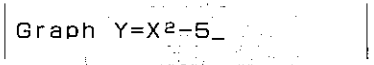
[F2](Zoom)



Example 1 **To use Auto Range to graph $y = x^2 - 5$ when the x-axis range is set as X min = −3 and X max = 5:**

Input the function to draw the graph.

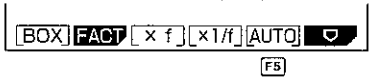
[SHIFT][SETUP][F1](RECT)[EXIT]
[SHIFT][F5](Cls)[EXE]
[Graph][X,θ,T][x^2][−][5]



[EXE]

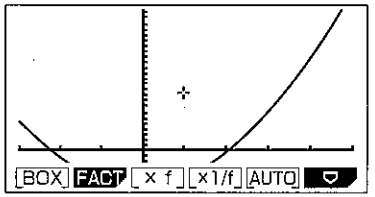
Press [F2](Zoom) to display the first Zoom/Auto Range menu.

[F2](Zoom)



Press [F5](AUTO) to draw the graph.

[F5](AUTO)



- Pressing [EXIT] twice or [SHIFT][QUIT] clears the menu from the bottom of the display.

Example 2 **To use Auto Range to graph the following functions when the x-axis range is set as X min = −4 and X max = 6:**

$y = (x + 2)(x - 4)$
$y = -(x + 2)(x - 4)$
$y = 2x + 4$
$y = -2x - 4$

Input the function to draw the graph.

[SHIFT][SETUP][F1](RECT)[EXIT]
[SHIFT][F5](Cls)[EXE]
[Graph][(][X,θ,T][+][2][)][(]
[X,θ,T][−][4][)][SHIFT][↵]
[Graph][(−)][(][X,θ,T][+][2][)]
[(][X,θ,T][−][4][)][SHIFT][↵]
[Graph][2][X,θ,T][+][4][SHIFT][↵]
[Graph][(−)][2][X,θ,T][−][4]

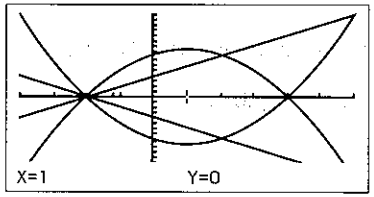
```
Graph Y=(X+2)(X-4)↵
Graph Y=-(X+2)(X-4)↵
Graph Y=2X+4↵
Graph Y=-2X-4_
```

[EXE]

[F2](Zoom)

```
[BOX][FACT][x f][x1/f][AUTO][▽]
                              [F5]
```

[F5](AUTO)
[EXIT][EXIT]



Notes

- In the COMP, SD, REG, and MAT Modes, Auto Range is valid only for the last six graphs drawn. In the GRAPH Mode, Auto Range is valid for all graphs drawn.
- You cannot use Auto Range inside of a program.
- When Auto Range is used inside of a multistatement formed using colons only, Auto Range parameters are applied throughout the multistatement, even in sections that do not contain graph functions.
- When Auto Range is used in a statement that uses a display result command to draw a graph, Auto Range parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overwrite rules.

■Graph Adjust

This function adjusts the scale of the x-axis and y-axis ranges so that their ratio equals 1. It is helpful when drawing circle graphs. This function is available from the second Zoom/Auto Range menu.

[F2](Zoom)[F6](▽)

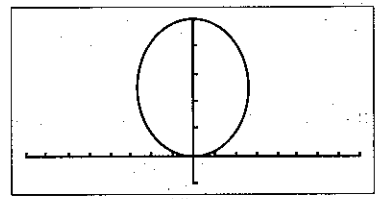
```
[ORG][SQR][RND]
              [F2]
```

Example **To use Graph Adjust to draw the graph for $r = 5 \sin \theta$. The range parameters should be set as shown here:**

```
Range
Xmin  : -8
 max  : 8
 scale: 1
Ymin  : -1
 max  : 5
 scale: 1
[INIT][TRIG]
```

Draw the graph.

[SHIFT][SETUP][F2](POL)[EXIT]
[SHIFT][F5](Cls)[EXE]
[Graph][5][sin][X,θ,T][EXE]



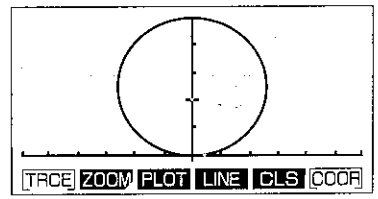
[F2](Zoom)[F6](▽)

```
[ORG][SQR][RND]
              [F2]
```

Adjust the graph.

[F2](SQR)

- The graph becomes a circle.



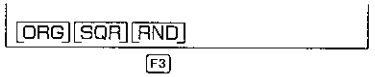
Notes

- In the COMP, SD, REG, and MAT Modes, Graph Adjust is valid only for the last six graphs drawn. In the GRAPH Mode, Graph Adjust is valid for all graphs drawn.
- You cannot use Graph Adjust inside of a program.
- When Graph Adjust is used inside of a multistatement formed using colons only, Graph Adjust parameters are applied throughout the multistatement, even in sections that do not contain graph functions.
- When Graph Adjust is used in a statement that uses a display result command to draw a graph, Graph Adjust parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overwrite rules.

■Coordinate Rounding

Coordinate Rounding rounds the coordinate values at the current pointer location to the optimum number of significant digits (page 186). It is helpful when you are using the Trace and Plot. This function is available from the second Zoom/Auto Range menu.

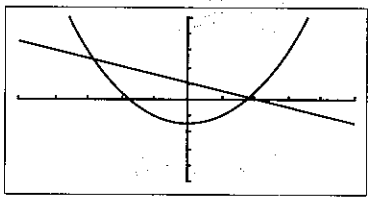
[F2](Zoom)[F6](▽)



Example **To use Coordinate Rounding to round the coordinates when the pointer is located at the points of intersection for the two graphs drawn on page 186. Use the same range parameters as in the example on page 186.**

Input the functions and draw the graph.

[SHIFT][SETUP][F1](RECT)[EXIT]
[SHIFT][F5](Cls)[EXE]
[Graph][X,θ,T][x²][−][3][SHIFT][↵]
[Graph][←][X,θ,T][+][2][EXE]

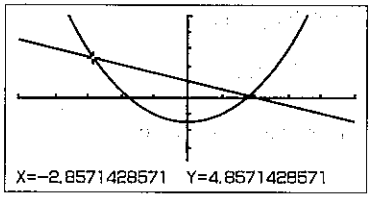


Activate Trace.

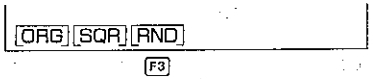
[F1](Trace)

Move the pointer to the first intersection.

[▶] ~ [▶]



[F2](Zoom)[F6](▽)

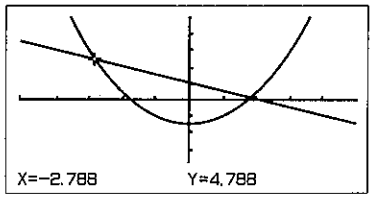


Round the coordinates.

[F3](RND)

Active Trace.

[F1](Trace)[EXIT]



Move the pointer to the other intersection.

[▶] ~ [▶]

- The coordinates at the current pointer location are rounded.

Notes

- In the COMP, SD, REG, and MAT Modes, Coordinate Rounding is valid only for the last six graphs drawn. In the GRAPH Mode, Coordinate Rounding is valid for all graphs drawn.
- You cannot use Coordinate Rounding inside of a program.
- When Coordinate Rounding is used inside of a multistatement formed using colons only, Coordinate Rounding parameters are applied throughout the multistatement, even in sections that do not contain graph functions.
- When Coordinate Rounding is used in a statement that uses a display result command to draw a graph, Coordinate Rounding parameters are applied up to the display result command, but any graphs drawn after the display result command are drawn according to normal graph overwrite rules.

■Using the Overwrite Function

You can use the following format, specifying your own values for the value memory where indicated, to draw more than one graph on the display at the same time.

[Graph] function [SHIFT][,][ALPHA][(] value memory [SHIFT][PRGM][F2](REL)[F1](=) any value [SHIFT][,] any value [SHIFT][,] ... any value [ALPHA][)][EXE]

Notes

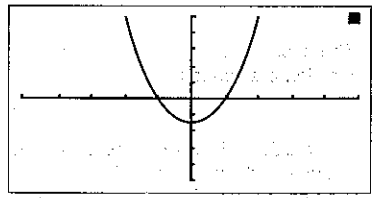
- Only one value for substitution of values can be used in the above format.
- X, Y, r, θ, and T cannot be specified as the value memory.
- If simultaneous graphing (SIMUL GRAPH) is ON, graphs for each of the variable values are drawn simultaneously (page 23).
- The above format can be used with rectangular coordinate, polar coordinate, and parametric functions, and with inequalities only.

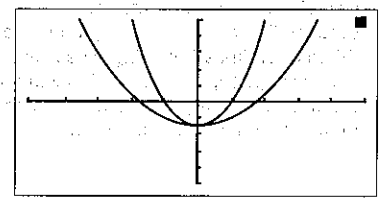
• To overwrite graphs

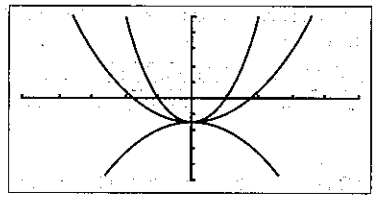
Example To draw graphs by substituting the values 3, 1, and −1 for A in the function $y = Ax^2 - 3$. Use the following range parameters:

```
Range
Xmin  : -5
 max  : 5
 scale: 1
Ymin  : -10
 max  : 10
 scale: 2
[INIT] [TRIG]
```

[SHIFT] [SETUP] [F1](RECT) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[Graph] [ALPHA] [A] [X,θ,T] [x^2] [−] [3]
[SHIFT] [,] [ALPHA] [(] [ALPHA] [A]
[SHIFT] [PRGM] [F2](REL) [F1](=)
[3] [SHIFT] [,] [1] [SHIFT] [,] [(−)] [1]
[ALPHA] [)] [EXE]







8-13 Some Graphing Examples

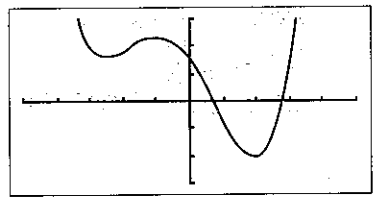
The following examples are presented to show you some ways that the graphing functions can be used effectively.
Note that all of these examples are performed in the COMP Mode.

Example 1 To graph the function $y = x^4 + 4x^3 - 36x^2 - 160x + 300$:

Use the following range parameters.

```
Range
Xmin  : -10
 max  : 10
 scale: 2
Ymin  : -600
 max  : 600
 scale: 200
[INIT] [TRIG]
```

[SHIFT] [SETUP] [F1](RECT) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[Graph] [X,θ,T] [^] [4] [+] [4] [X,θ,T] [^] [3]
[−] [3] [6] [X,θ,T] [x^2] [−] [1] [6] [0] [X,θ,T]
[+] [3] [0] [0] [EXE]

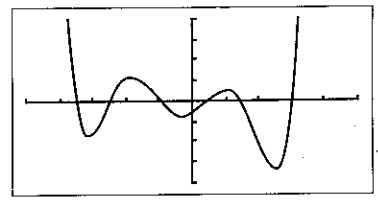


Example 2 To graph the function $y = x^6 + 4x^5 - 54x^4 - 160x^3 + 641x^2 + 828x - 1260$:

Use the following range parameters.

```
Range
Xmin  : -10
 max  : 10
 scale: 2
Ymin  : -8000
 max  : 8000
 scale: 2000
[INIT] [TRIG]
```

[SHIFT] [SETUP] [F1](RECT) [EXIT]
[SHIFT] [F5](Cls) [EXE]
[Graph] [X,θ,T] [^] [6] [+] [4] [X,θ,T] [^] [5]
[−] [5] [4] [X,θ,T] [^] [4] [−] [1] [6] [0]
[X,θ,T] [^] [3] [+] [6] [4] [1] [X,θ,T] [x^2]
[+] [8] [2] [8] [X,θ,T] [−] [1] [2] [6] [0] [EXE]

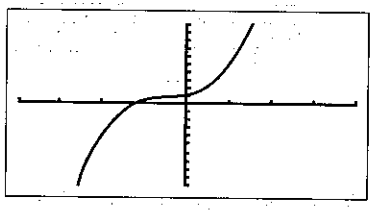


Example 3 To store x^3+1, x^2+x into Function Memory (page 40), and then graph: $y=x^3+x^2+x+1$

Use the following range parameters:

```
Range
Xmin   : -4
 max   : 4
 scale : 1
Ymin   : -10
 max   : 10
 scale : 1
[INIT] [TRIG]
```

[SHIFT] [SETUP] [F1](RECT) [EXIT]
[AC]
[X,θ,T] [^] [3] [+] [1] [SHIFT] [FMEM] [F1](STO) [1]
[AC](stores (x^3+1))
[X,θ,T] [x^2] [+] [X,θ,T] [F1](STO) [2]
[AC](stores (x^2+x))
[SHIFT] [F5](Cls) [EXE]
[Graph] [F3](fn) [1] [+] [F3](fn) [2] [EXE]



Chapter 9

Dual Graph

Chapter 9 Dual Graph

Dual Graph lets you split the display between two different screens, which you can then use to draw different graphs at the same time. Dual Graph gives you valuable graph analysis capabilities.

Important

You should be familiar with the contents of "8-10 Storing Functions in Memory" on page 169 before reading this chapter.

9-1 Before Using Dual Graph

Before using Dual Graph, you must first use the Graph Mode's set up display to switch Dual Graph on.

[MENU](Graph)[EXE]
[SHIFT][SETUP][▼][▼][▼]

Press [F1](ON) to switch Dual Graph on.

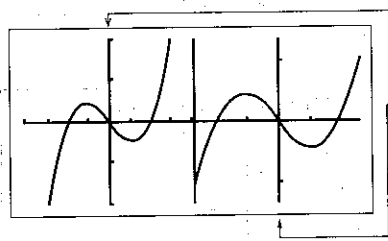
[EXIT]

```
GRAPH  FUNC:RECT
 Y1  :
 Y2  :
 Y3  :
 Y4  :
 Y5  :
STO RCL TYPE ▸ SEL DRAW
 F1  F2  F3  F4  F5  F6
```

- Note that "," does not appear above function key [F4] when GRAPH TYPE is set as PARAM (page 170).
- For further details about the function key menu at the bottom of the display, see page 169.

■About Dual Graph Screen Types

The screen on the left side of the display is called the *active screen*, and the graph on the left side of the display is called the *active graph*. Conversely, the right side is the *inactive screen* containing the *inactive graph*. Any function that you execute while using Dual Graph is always applied to the active graph. To execute a function on the right-side inactive graph, you must first make it active by moving it into the active screen.



Active Screen
Actual graph drawing is done here.

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

- Indicators appear to the right of the formulas in the function memory list to tell where graphs are drawn with Dual Graph.

```
GRAPH  FUNC:RECT
▶Y1   =X(X+1)(X-1)   R
▶Y2   =2X²-3         B
STO RCL TYPE      SEL DRAW
```

R — Indicates inactive graph (on right side of display)
B — Indicates graph drawn on both sides of display

If you redraw graphs in the situation shown above, the function marked "R" is drawn as the inactive graph, while "B" is drawn using both sides of the display.
If you perform the sequence [F5](SEL)[F2](CAN)[F1](SET), the "R" and "B" indicators are cleared, and the graphs are drawn as active graphs.

9-2 Specifying the Left and Right Display Range Parameters

You must specify different range parameters for the left and right sides of the display.

• To specify display range parameters

Press [Range] to display the Range Parameter Screen for the left-side graph.

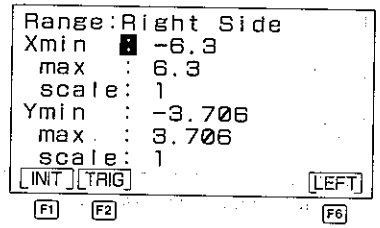
[Range]

```
Range:Left Side
Xmin  : -6.3
 max  :  6.3
 scale:  1
Ymin  : -3.706
 max  :  3.706
 scale:  1
INIT TRIG          RIGHT
 F1   F2            F6
```

[F1](INIT) ..... Initialization of range values
[F2](TRIG) ..... Initialization of range values to match trigonometric units
[F6](RIGHT) ..... Right side range parameter settings

To display the Range Parameter Screen for the right side, press [F6](RIGHT) while the left-side Range Parameter Screen is displayed.

[F6](RIGHT)



[F1](INIT) ..... Initialization of range values
[F2](TRIG) ..... Initialization of range values to match trigonometric units
[F6](LEFT) ..... Left side range parameter settings

- To actually specify range parameters display one of the Range Parameter Screens and use the procedures described under "To specify range parameters" on page 147 to input parameter values.
- Use the following key operations to change to different screens while inputting range parameters for the left and right side screens.

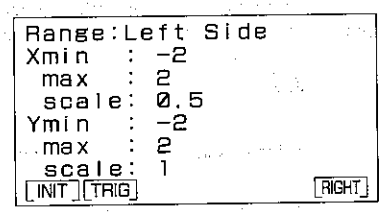
	[Range]	[F6]
While the range parameter setting screen for the active graph is shown	Changes in the sequence: range parameter setting screen 1 → range parameter setting screen 2 → function memory list	Displays the inactive graph range parameter setting screen.
While the range parameter setting screen for the inactive graph is shown	Changes in the sequence: range parameter setting screen 1 → range parameter setting screen 2 → function memory list	Displays the active graph range parameter setting screen.

9-3 Drawing a Graph in the Active Screen

You can draw graphs only in the active screen. You can then copy or move the graph to the inactive screen.

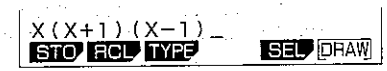
• To draw a graph in the active screen

Example **To draw the graph of $y = x(x + 1)(x - 1)$ using the following range parameters:**



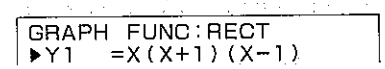
Input the function.

[X,θ,T] [(] [X,θ,T] [+] [1] [)]
[(] [X,θ,T] [−] [1] [)]



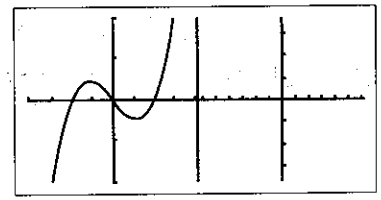
Store the function.

[F1](STO)[F6](SET)



Draw the graph.

[F6](DRAW)



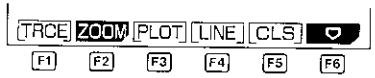
9-4 Displaying a Graph in the Inactive Screen

There are two methods you can use to display a graph in the inactive screen. You can copy a graph from the active screen to the inactive screen, or you can move the graph from the active screen to the inactive screen. In both cases, you must first draw the graph in the left-side active screen.

■Before Displaying a Graph in the Inactive Screen

After drawing a graph in the active screen, press [SHIFT], and the first Dual Graph function menu appears at the bottom of the display.

[SHIFT]

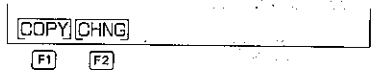


The following describes of operations available in the function menu at the bottom of the display.

- [F1](TRCE) ..... Trace function (page 186)
- [F2](ZOOM) ..... Zoom function (page 201)
- [F3](PLOT) ..... Plot function (page 192)
- [F4](LINE) ..... Line function (page 195)
- [F5](CLS) ..... Clears the pointer and coordinates from the active screen graph and redraws the graph only
- [F6](▽) ..... Second Dual Graph function menu

Press [F6](▽) and the function menu changes as shown here.

[F6](▽)

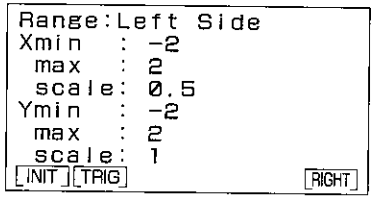


- [F1](COPY) ..... Copies active graph to inactive screen
- [F2](CHNG) ..... Switches active screen and inactive screen

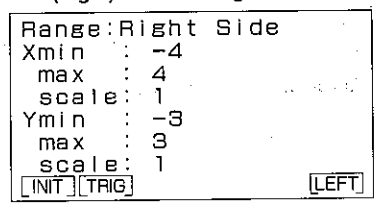
■To Copy the Active Graph to Inactive Screen

Example **To draw the graph for $y = x(x + 1)(x - 1)$ on the active screen and the inactive screen, using the following range parameters:**

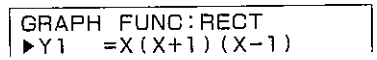
Active (Left) Screen Range Parameters



Inactive (Right) Screen Range Parameters

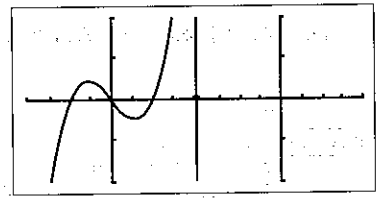


Assume that the function being graphed is stored in memory area Y1.



Draw the graph in the active screen.

[F6](DRAW)

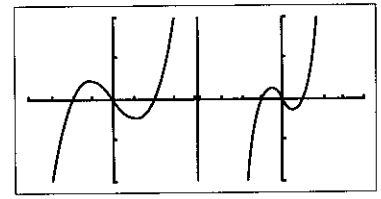


Display the second Dual Graph function menu.

[SHIFT][F6](▽)

Copy the graph to the inactive (right) screen.

[F1](COPY)



•The graph is reproduced using the inactive screen range parameters.

■To Switch the Contents of the Active and Inactive Screens

Example **To switch the screens produced by the preceding example:**

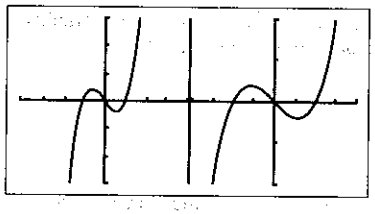
Display the second Dual Graph function menu.

SHIFT F6(▽)

```
COPY CHNG
      F2
```

Switch the screens.

F2(CHNG)



Important

Note that using F2(CHNG) to switch the screens also switches their range parameters.

■To Draw Different Graphs on the Active Screen and Inactive Screen

Example **To draw the graphs of the following functions on the screens noted:**
Active Screen: $y = x(x + 1)(x - 1)$
Inactive Screen: $y = 2x^2 - 3$

Use the following range parameters.

Active (Left) Screen Range Parameters

```
Range:Left Side
Xmin  : -4
 max  : 4
 scale: 1
Ymin  : -5
 max  : 5
 scale: 1
INIT TRIG          RIGHT
```

Inactive (Right) Screen Range Parameters

```
Range:Right Side
Xmin  : -2
 max  : 2
 scale: 0.5
Ymin  : -2
 max  : 2
 scale: 1
INIT TRIG          LEFT
```


Assume that the functions being graphed are stored in memory areas Y1 and Y2.

```
GRAPH FUNC:RECT
▶Y1   =X(X+1)(X-1)
▶Y2   =2X²-3

STO RCL TYPE        SEL DRAW
                     F5
```

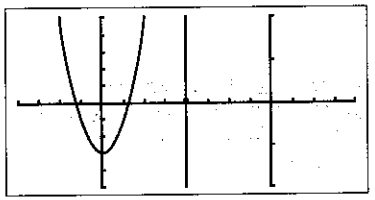
Select the function for the graph that you want to end up in the inactive (right) screen.

F5(SEL)F2(CAN)

```
GRAPH FUNC:RECT
▷Y1   =X(X+1)(X-1)
▶Y2   =2X²-3

SET CAN             DRAW
                     F6
```

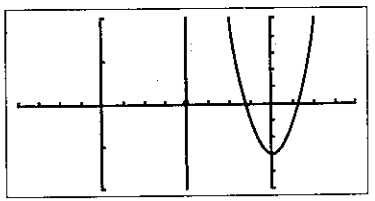
Draw the graph in the active screen.

F6(DRAW)



Display the second Dual Graph function menu and move the graph to the inactive (right) screen.

SHIFT F6(▽)
F2(CHNG)



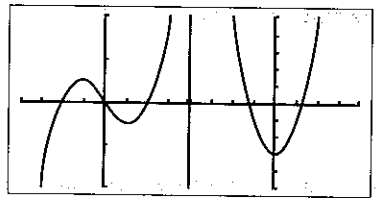
Select the function for the graph that you want in the now-empty active (left) screen.

AC
F5(SEL)F1(SET)

```
GRAPH FUNC:RECT
▷Y1   =X(X+1)(X-1)
 Y2   =2X²-3

SET CAN             DRAW
                     F6
```

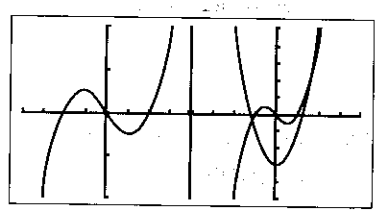
Draw the graph.

F6(DRAW)



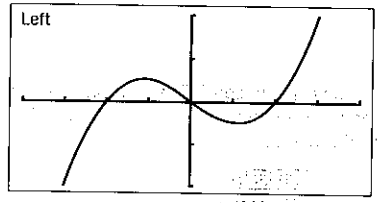
•At this point, you could perform a copy operation and superimpose the active graph over the inactive graph.

SHIFT F6(▽)
F1(COPY)

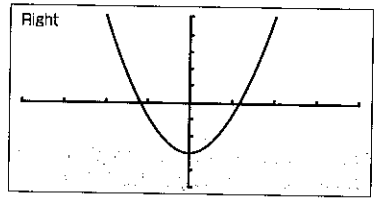


•Pressing G↔T lets you switch between display of the active and inactive graphs, using the entire display for each.

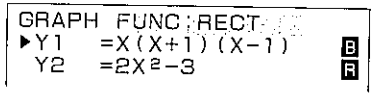
G↔T



G↔T



G↔T



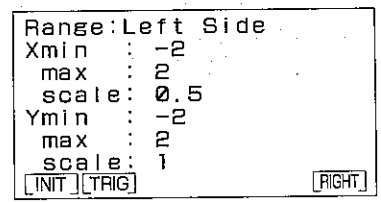
■Other Graph Functions with Dual Graph

After drawing a graph using Dual Graph, you can use the Trace, Zoom, Plot, Line, Scroll, and Auto Range functions. Note, however, that these functions are available only for the active (left) graph. For details on using these functions, see "8-12 Other Graph Functions" on page 185.

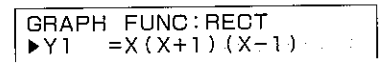
- To perform any of the above operations on the inactive graph, first move the inactive graph to the active screen.
- The graph screen will not scroll while a Trace operation is being performed on the active graph.

The following shows some example operation using the Zoom function.

Example 1 **To use Box Zoom to enlarge the graph of $y = x(x + 1)(x - 1)$. Use the following range parameters for the graph:**



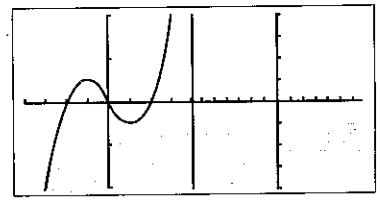
Assume that the function is already stored in memory area Y1.



F6

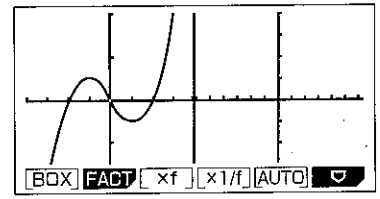
Draw the graph.

F6(DRAW)



Display the pointer in the center of the active graph.

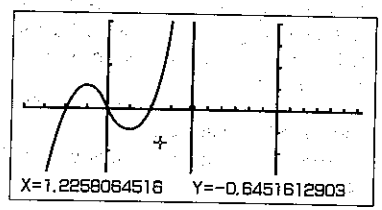
SHIFT F2(ZOOM)



F1

Specify one corner of the area to be enlarged.

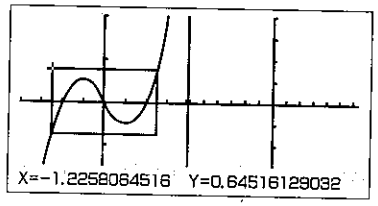
F1(BOX)
▲ ~ ▼▶ ~ ▶
EXE



•Use the cursor keys to move the pointer to the location you want.

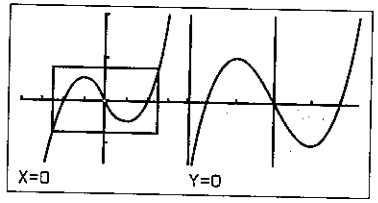
Move the pointer to the other corner of the area to be enlarged.

▲ ~ ▲◀ ~ ◀

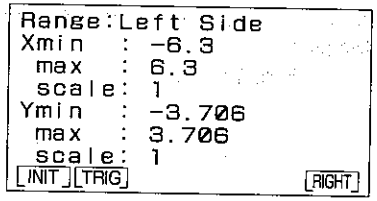


Enlarge the graph.

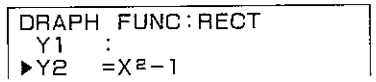
EXE



Example 2 **To use Factor Zoom to enlarge the graph of $y = x^2 - 1$ by a factor of 3 on the x-axis and a factor of 2 on the y-axis. Use the following range parameters for the graph:**



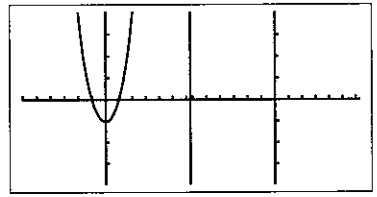
Assume that the function is already stored in memory area Y2.



F6

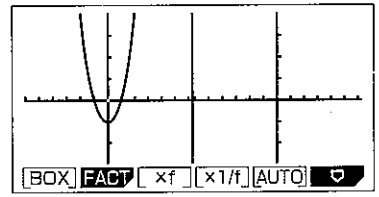
Draw the graph.

F6(DRAW)



Display the pointer in the center of the active graph.

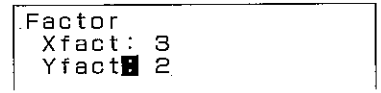
SHIFT F2(ZOOM)



F2

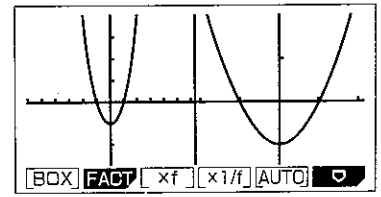
Input the zoom factors.

F2(FACT)3EXE



Enlarge the graph.

EXIT F3(×f)



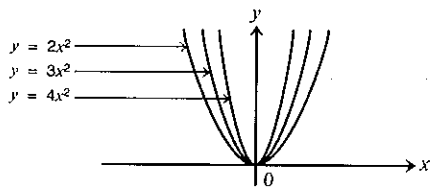
•The range parameters of the inactive screen are always changed by a Zoom operation, so if there is a graph already on the inactive screen it is cleared before the result of the Zoom operation is drawn there.

Chapter 10

Dynamic Graphing

Chapter 10 Dynamic Graphing

The Dynamic Graph Mode of this calculator gives you real-time representations of changes in a graph as coefficients and terms are changed. It lets you see what happens to a graph when such changes are made. For example, you can see the graph change as illustrated here as the value of coefficient a changes in the formula $y = ax^2$.



10-1 Before Using the Dynamic Graph Mode

To use the Dynamic Graph Mode, select the **DYNA** icon from the Main Menu. When you do, the initial Dynamic Graph Mode screen appears as shown here.

MENU
▲▼◀▶
EXE

```
DYNAMIC GRAPH
▶Y=AX+B
 Y=A(X+B)²+C
 Y=AX²+BX+C
 Y=AX^3+BX²+CX+D
 Y=Asin (BX+C)        ↓
NEW EDIT DEL
 F1   F2   F3
```

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

F1(NEW) ..... Input of a new equation
F2(EDIT) ..... Editing of an existing equation
F3(DEL) ..... Deletion of an existing equation

•The calculator comes preprogrammed with the following seven equations, which can be edited, deleted, or used as they are.

Y = AX + B
Y = A (X + B)² + C
Y = AX² + BX + C
Y = AX^3 + BX² + CX + D
Y = Asin (BX + C)
Y = Acos (BX + C)
Y = Atan (BX + C)

•If there are no equations stored in memory, the message "No Func in Memory" appears on the display when you enter the Dynamic Graph Mode.

10-2 Inputting a New Equation

Use the following procedure to input a new equation.

• To input a new equation

Example **To input the equation $y = A(Bx - C)^2 + D$:**

F1(NEW)

```
Y=_
  <NEW GRAPH FUNC>  SAVE
```

Input the equation.

ALPHA A (ALPHA B X,θ,T
− ALPHA C) x² + ALPHA D

```
Y=A(BX−C)²+D_
  <NEW GRAPH FUNC>  SAVE
                     F6
```

Store the equation in memory.

F6(SAVE)

```
DYNAMIC GRAPH
▶Y=A(BX−C)²+D
```

•The new function appears at the top of stored functions.

Notes

•You can use any alphabetic character from A through Z as a variable in an equation, except for X, Y, T, r, and θ.
•If you want to input coefficient values (page 236) before storing the equation into memory, press EXE instead of F6(SAVE).
•If there is not enough memory to store your equation when you press F6(SAVE), the an error (Mem ERROR) occurs. When this happens, press AC to clear the error message.
•If there is no variable in the formula you input, the message "Variable none!" appears on the display. When this happens, press AC to clear the error message.

10-3 Editing a Function

Use the following procedures to modify a function that is already stored in memory to create a new one.

Important

•When you edit a function to create a new one, the original function is deleted.

• To edit a function

Example **To change the second function stored in memory from $y = A(x + B)^2 + C$ to $y = A(x + B)^2 - C$:**

Move the pointer to the function you want to change.

▼

```
DYNAMIC GRAPH
 Y=AX+B
▶Y=A(X+B)²+C

NEW EDIT DEL
```
F2

F2(EDIT)

```
Y=A(X+B)²+C_
     <EDIT FUNC>   SAVE
```

◀◀■

```
Y=A(X+B)²-C
     <EDIT FUNC>   SAVE
```
F6

Save the new equation.

F6(SAVE)

```
DYNAMIC GRAPH
▶Y=A(X+B)²-C
 Y=AX+B
```

•The new function appears at the top of stored functions.

10-4 Deleting a Function

Use the following procedure to delete a function from memory.

• To delete a function

Example **To delete the third function, $y = Ax^2 + Bx + C$.**

Move the pointer to the equation that you want to delete.

▼▼

```
DYNAMIC GRAPH
 Y=AX+B
 Y=A(X+B)²+C
▶Y=AX²+BX+C
 Y=AX^3+BX²+CX+D
 Y=Asin (BX+C)        ↓

NEW EDIT DEL
```
F3

F3(DEL)

```
YES    DELETE OK?    NO
```
F1

Press F1(YES) to delete the selected equation, or F6(NO) to abort the operation without deleting anything.

F1(YES)

```
DYNAMIC GRAPH
 Y=AX+B
 Y=A(X+B)²+C
▶Y=AX^3+BX²+CX+D
 Y=Asin (BX+C)
 Y=Acos (BX+C)        ↓

NEW EDIT DEL
```

10-5 Drawing a Dynamic Graph

The following is the general procedure you should use to draw a Dynamic Graph.

1. Select or input a function.
2. Define the dynamic variable.
   •This is the variable whose value changes in order to produce the different graphs.
3. Assign values to each of the coefficients of the function.
4. Set the range of the dynamic variable.
5. Draw the Dynamic Graph.

Each of these steps is covered in detail below, using the following example.

Example **To draw the Dynamic Graph for $y = A(x - 1)^2 - 1$, as A changes from 2 through 5 in increments of 1. Use the range parameter shown here for the graph:**

```
Range
Xmin  : -2
 max  : 3
 scale: 1
Ymin  : -2
 max  : 4
 scale: 1
INIT TRIG
```

• To set up for a Dynamic Graph

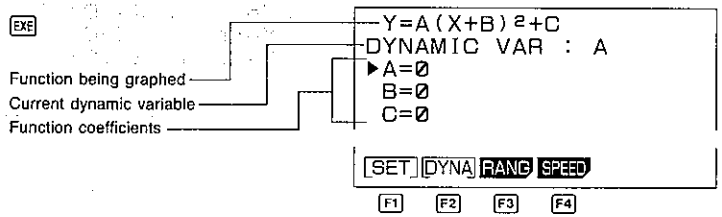
Select the function whose graph you want to draw.

(▼)

```
DYNAMIC GRAPH
 Y=AX+B
▶Y=A(X+B)²+C
```

Display the menu for input of coefficient values.

EXE



The following describes the operations available in the function menu at the bottom of the display.

F1(SET) ..... Definition of dynamic variable
F2(DYNA) ..... Start of Dynamic Graph drawing
F3(RANG) ..... Range parameter setting display
F4(SPEED) ..... For checking of graph drawing speed after drawing of Dynamic Graph

- Variable-A is automatically selected as the dynamic variable. If you want to make another variable the dynamic variable, move the pointer to that variable and press F1(SET).
- The values stored in memory for each of the coefficients appears on the display. If a variable is assigned a complex number, only the integer part appears on the display.

Assign values to each of the coefficients.

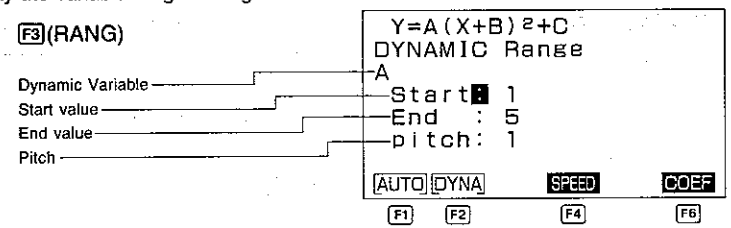
2 EXE
(−) 1 EXE
(−) 1 EXE

```
 Y=A(X+B)²+C
DYNAMIC VAR : A
 A=2
 B=−1
▶C=−1
SET DYNA RANG SPEED
```
F3

- Use (▲) and (▼) to move the pointer next to the coefficient whose value you want to input and input the value.
- When you input a value for a coefficient, the value is stored in the corresponding value memory.

Display the variable range setting menu.

F3(RANG)



The following describes of operations available in the function menu at the bottom of the display.

F1(AUTO) ..... For automatic setting of default range values
F2(DYNA) ..... Start of Dynamic Graph drawing
F4(SPEED) ..... For checking of graph drawing speed after drawing of Dynamic Graph
F6(COEF) ..... Coefficient input display

- Range values are retained in memory until you change them.
- Pressing F1(AUTO) draws the Dynamic Graph for up to 11 values, starting from the start value.

Input the variable range values.

2 EXE

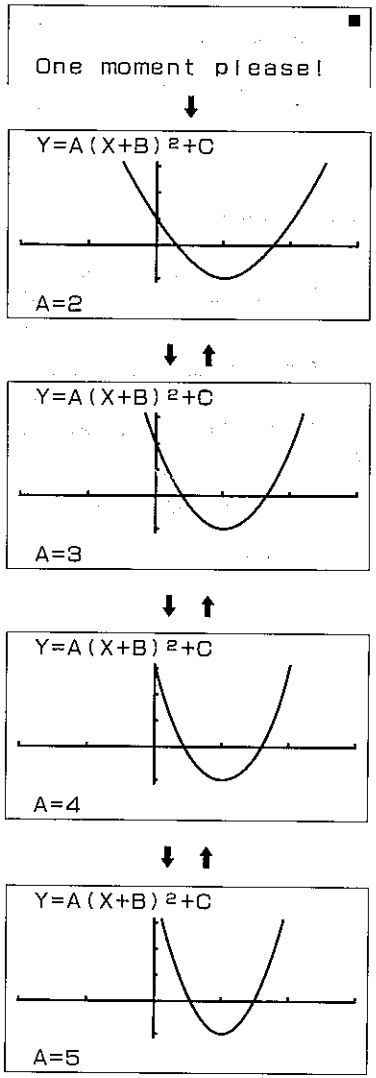
```
 Y=A(X+B)²+C
DYNAMIC Range
A
 Start: 2
 End : 5
 pitch: 1
```


A313043-2

• To start Dynamic Graph drawing

After setting up for a Dynamic Graph, press [F2](DYNA) to begin the actual drawing process.

[F2](DYNA)



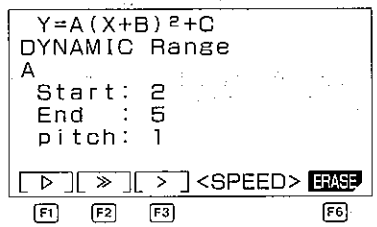
- While the message "One moment please!" is shown on the display, you can press [AC] to interrupt drawing of the graph and return to the coefficient input display.
- You can interrupt Dynamic Graph drawing at any time by pressing [AC].
- If you do not want the function and coefficient values shown on the display with the graph, use the graph function set up display (page 23) to switch GRAPH FUNC off.

Notes

- Depending on the graph drawing set up you use, it may take some time before the drawing of a Dynamic Graph appears on the display.
- Dynamic Graphs are drawn using rectangular coordinates, regardless of the graph type setting (page 22).
- After you interrupt drawing of a Dynamic Graph by pressing [AC], you cannot use Trace, Zoom, and other analysis functions.
- You cannot use the Overwrite function with Dynamic Graphs.

• To change the drawing speed

[AC][G-T]



The following describes of operations available in the function menu at the bottom of the display.

[F1](▷) ..... NORMAL
[F2](≫) ..... FAST (double NORMAL)
[F3](>) ..... SLOW (half NORMAL)
[F6](ERASE) ..... Deletes Dynamic Graph screen data (see below)

Press function key [F1], [F2], or [F3] to select the drawing speed you want.

• To check Dynamic Graph drawing speed

Use the following procedure to check the drawing speed after drawing a Dynamic Graph.

AC G-T EXIT F4 (SPEED)

Drawing speed

```
DYNAMIC SPEED CONTROL
DYNAMIC SPEED : ▷
▶NORMAL : ▷
  FAST  : ≫
  SLOW  : >
[SET] [DYNA] [RANG]  [COEF]
```

•Dynamic graph drawing is always performed starting from NORMAL speed.

• To delete Dynamic Graph screen data

AC G-T F6 (ERASE)

```
[YES] ERASE DYNAMIC? [NO]
 F1                   F6
```

Press F1 (YES) to delete the Dynamic Graph Screen data, or F6 (NO) to abort the operation without deleting anything.

Chapter 11

Table and Graph Mode

Chapter 11 Table and Graph Mode

This chapter describes how to use the Table and Graph Mode for quick and simple solution of equations for a series of values, and plotting of the results.

11-1 Entering the Table and Graph Mode

Select the **TABLE** icon on the Main Menu.

[MENU]
[▲][▼][◀][▶]
[EXE]

```
TABLE&GRAPH
G-func  :ON
angle   :Deg
display :Norm1
M-D/Cpy :M-Disp
F1:FUNCTION
F2:RECURSION
FUNC RECR
```

[F1] [F2]

The following are the meanings for the function key menu at the bottom of the screen. Press the function key that corresponds to the type of operation you want to perform.

[F1](FUNC) ..... Function
[F2](RECR) ..... Recursion

11-2 Generating a Table and Drawing a Graph for a Function

Use the following procedure to input a function, create a table, and draw a graph.

• To input the function and generate a numeric table

Example **To input the function $y = 3x^2 - 2$ and generate a numeric table based on a variable multiplied by the value 0 through 6 in increments of 1:**

Enter the Table & Graph Mode for a function.

[MENU](TABLE)[EXE]

[F1](FUNC)

```
FUNCTION

INPUT FUNC FORMULA


Y=_
[TABL] RANG
```

•If there is already a function stored in memory, its numeric table appears on the display. In that case, you should press [F1](NEW) and then [F1](YES) to proceed (see page 248).

Input the function.

[3][X,θ,T][x²][−][2]

```
Y=3X²−2_
[TABL] RANG
```

[F2]

Press [F2](RANG) for the table range setting display.

[F2](RANG)

```
TABLE Range
X

 Start: 1
 End  : 5
 pitch: 1

[TABL]
```

[F1]

The table range parameters define the conditions for the x-variable used when generating a function table. These parameters determine how the x-variable changes, as shown below.

Start ..... Starting value of x-variable
End ..... Ending value of x-variable
pitch ..... Change of x-variable. A positive value increments x, while a negative value decrements x.

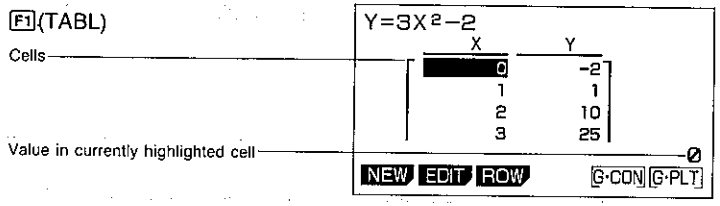
Input the range values.

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

```
 Start: 0
 End  : 6
 pitch: 1

[TABL]
```

[F1]

Press [F1](TABL) to display the function table.



- Each cell can hold up to eight digits if a value is positive, or seven digits if the value is negative. With exponential display, only two digits are allowed for the exponent.
- You can use the cursor keys to move the highlighting around the display.

Notes

- Only one table can be stored in memory at one time.
- When START < END while PITCH < 0, or when START > END while PITCH > 0, the absolute value of PITCH is used to change variable-x from START to END.
- When START = END and PITCH = 0, or |START − END| < PITCH, only the initial value of variable-x is used.
- Whenever a calculation error (Ma ERROR) occurs, the x-data and y-data (calculation results) do not appear on the display.

■Editing Function and Table Data

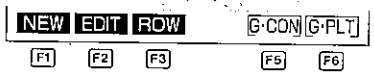
The following editing functions can be performed on table data.

- **Change of variable x for a table**
- **Deletion, insertion, and adding of table lines**
- **Editing of the function**
- **Deletion of the function and input of a new one**
- **Drawing of a connected-point graph for the function**
- **Drawing of plotted-point graph for the function table**

• To start an editing operation

Use one of the two following procedures to start an editing operation. The procedure you use will depend on whether or not a function and table are already stored in memory.

- To edit a function already stored in memory, enter the Table & Graph Mode and then press [F1](FUNC) to display the function's table along with the table function menu.
- To edit a new function and table, first input the function. After you do, the table for the new function and the table function menu will appear on the display.



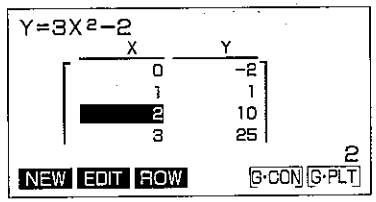
[F1](NEW) ..... Clears the function for new input
[F2](EDIT) ..... For editing the function
[F3](ROW) ..... For adding, inserting, deleting table rows
[F5](G·CON) ..... For drawing of a graph, connecting all points (page 248)
[F6](G·PLT) ..... For drawing of a graph, plotting all points without connecting them (page 248)

• To change an X-column value

Example **To change the value in X-column row 3 from 2 to 2.5:**

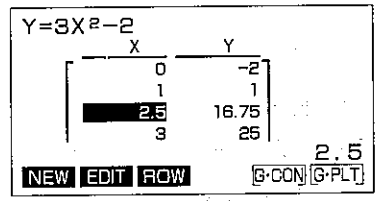
While the numeric table is displayed:

(▼)(▼)



[2] [•] [5]

[EXE]

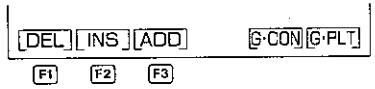


- You cannot change Y-column values.

■Row Operations

Use the following procedures to delete, insert, and add rows. To start a row operation, you should first press [F3](ROW) while the table function menu is displayed. Doing so causes the following row operation menu to appear.

[F3](ROW)

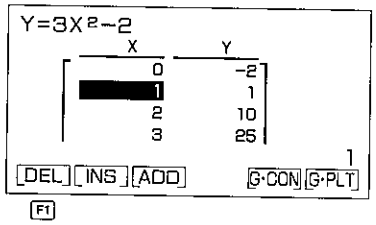


[F1](DEL) ..... Deletes the row containing the highlighted cell
[F2](INS) ..... Inserts a row above the row containing the highlighted cell
[F3](ADD) ..... Adds a row below the row containing the highlighted cell

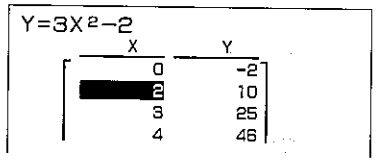
• To delete a row

Example To delete row 2:

[F3](ROW)
▼



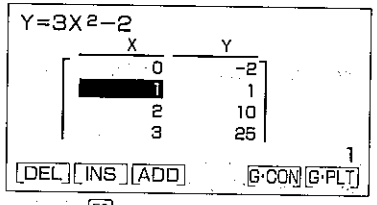
[F1](DEL)



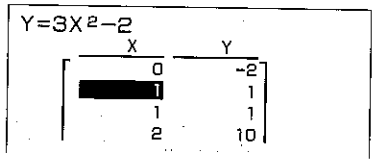
• To insert a row

Example To insert a row between rows 1 and 2:

[F3](ROW)
▼



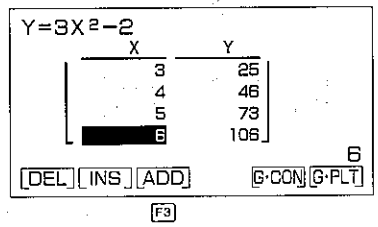
[F2](INS)



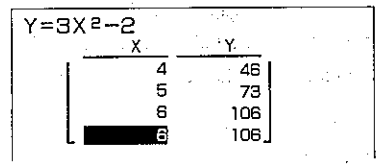
• To add a row

Example To add a row below row 6:

[F3](ROW)
▼▼▼▼▼▼



[F3](ADD)

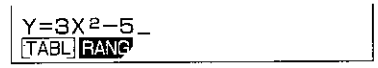


• To edit the function

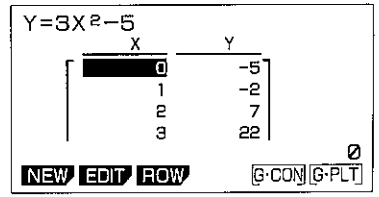
Example To change the function from $y = 3x^2 - 2$ to $y = 3x^2 - 5$:

[F2](EDIT)

◀5



[F1](TABL)



• To delete the function and table data for new input

While the table function menu is displayed, press [F1](NEW).

[F1](NEW)

```
[YES]  ERASE TABLE ?  [NO]
 F1                    F6
```

Press [F1](YES) to delete all the table's data and the function, or [F6](NO) to abort the operation without deleting anything.

■Drawing a Graph Using Table Data

There are two types of graph you can draw using table data. A connected-point graph can be drawn using the function stored in memory. A plotted-point graph can be drawn plotting only the points of the values in the table, without connecting them.

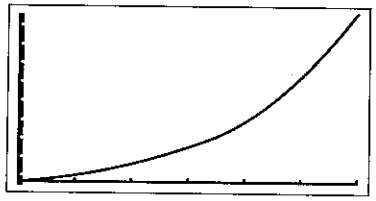
•Note that graphs using table data are always drawn using rectangular coordinates.

• To draw a connected-point graph

Example **To draw a connected-point graph of $y = 3x^2 - 2$, using the following range parameters:**

```
Range
Xmin  :  0
 max  :  6
 scale:  1
Ymin  : -2
 max  :  106
 scale:  2
[INIT] [TRIG]
```

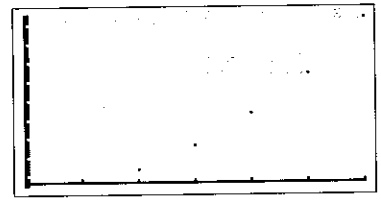
[F5](G·CON)



• To draw a plotted-point graph

Example **To draw a plotted-point graph of $y = 3x^2 - 2$, using the same range parameters as the example for the connected-point graph.**

[F6](G·PLT)



•Use one of the two following procedures to input another function after drawing a graph.

To edit the current function

1. While the graph is on the display, press [G↔T] to return to the numeric table for the function that was used to draw the graph.
2. Press [F2](EDIT) to make the cursor appear on the display.
3. Use the procedures on page 247 to edit the function.

To input a new function

1. While the graph is on the display, press [G↔T] to return to the numeric table for the function that was used to draw the graph.
2. Press [F1](NEW) and then [F1](YES) to delete the current function.
3. Use the procedures on page 248 to input a new function.

•Once you draw a graph, you can use Trace, Zoom, Plot, Line, and Scroll functions. See "8-12 Other Graph Functions" starting on page 185 for details.

11-3 Using the Table and Graph Mode with a Recursion Formula

You can input the following types of recursion formulas for generation of a numeric table and for graphing.

- **General term of sequence $\{a_n\}$, consisting of a_n and n**
- **Linear two-term recursion, consisting of a_{n+1}, a_n and n**
- **Linear three-term recursion, consisting of a_{n+2}, a_{n+1}, a_n and n**

• To set the recursion type

In the Table & Graph Mode, press [F2](RECR).

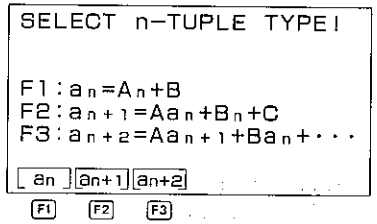
[F2](RECR)

```
RECURSION

INPUT  RECR  FORMULA


an=
[TABL] [RANG] [n]        [TYPE]
```

•If there is already a recursion formula stored in memory, its numeric table appears on the display. In that case, you should press [F1](NEW) and then [F1](YES) to proceed (see page 254).

Display the recursion type menu.

[F6](TYPE)



The following are the meanings for the function key menu at the bottom of the screen.

[F1](a_n) ..... a_n recursion
[F2](a_{n+1}) ..... a_{n+1} recursion
[F3](a_{n+2}) ..... a_{n+2} recursion

•In the expression [$a_n = A_n + B$] that is on the display, (a_n) represents general term [$a_n = A \times n + B$].

• To input a formula and generate a numeric table

Example 1 **To input the formula $a_n = 2_n + 1$, and generate a numeric table with n-variable changing values in a range of 1 through 6:**

Press [F1] (a_n) to specify the recursion type.

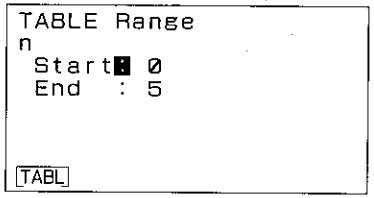
[F1](a_n)

Input the recursion formula.

[2][F3](n)[+][1]

Press [F2](RANG) for the table range specification display.

[F2](RANG)

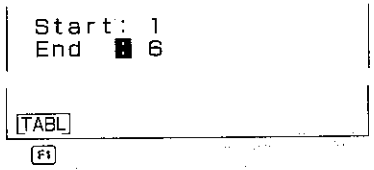


The table range parameters define the conditions for the n-variable used when generating a table for the recursion. These parameters determine how the n-variable changes, as shown below.

Start ..... Starting value of n-variable
End ..... Ending value of n-variable

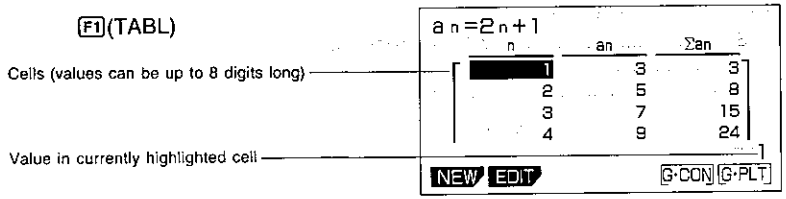
Input the range values.

[1][EXE][6][EXE]



Press [F1](TABL) to display the recursion table (consisting of each term and their sum). A menu of table functions also appears at the bottom of the display.

[F1](TABL)

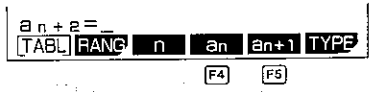


•You can generate a numeric table by inputting a non-linear exponential expression (such as $a_n = 2^n - 1$), fractional expression (such as $a_n = (n+1)/1$) or irrational expression (such as $a_n = \sqrt{n} - \sqrt{n-1}$) for n on general term (a_n).

Example 2 **To input $a_{n+2} = a_{n+1} + a_n$ and generate a numeric table with n-variable changing values in a range of 1 through 6. Note that $a_1 = 1$ and $a_2 = 1$:**

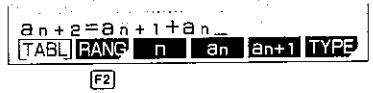
Press [F3](a_{n+2}) to specify the recursion type.

[F3](a_{n+2})



Input the recursion formula.

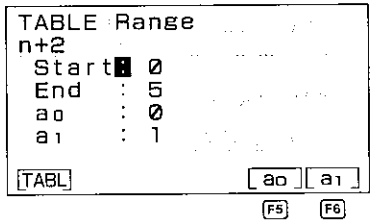
[F5](a_{n+1})[+][F4](a_n)



•Note that a_{n+1} does not appear above function key [F5] when you select a_{n+1} (linear two-term recursion) as the recursion type.

Press [F2](RANG) for the table range specification display.

[F2](RANG)



The following are the meanings for the function key menu at the bottom of the screen.

[F1](a_0) ..... For input of values for a_0 and a_1.
[F2](a_1) ..... For input of values for a_1 and a_2.

The table range parameters define the conditions for the n-variable used when generating a table for the recursion, and for sequence $\{a_n\}$. These parameters determine how the n-variable changes, as shown below.

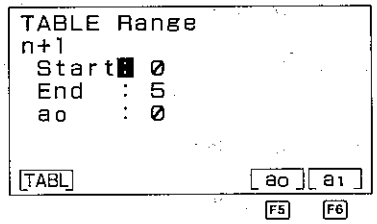
Start ..... Starting value of n-variable
End ..... Ending value of n-variable
a_0, a_1, a_2 ..... Values of terms a_0, a_1, a_2

• n-variable is incremented by 1.

Important

When a_{n+1} (linear two-term recursion) is selected as the recursion type, the table range specification display appears as shown here.

[F2](RANG)

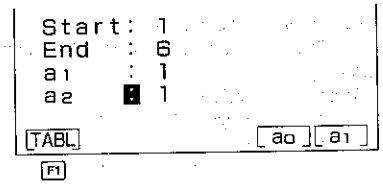


The following are the meanings for the function key menu at the bottom of the screen.

[F5](a_0) ..... For input of value for a_0.
[F6](a_1) ..... For input of value for a_1.

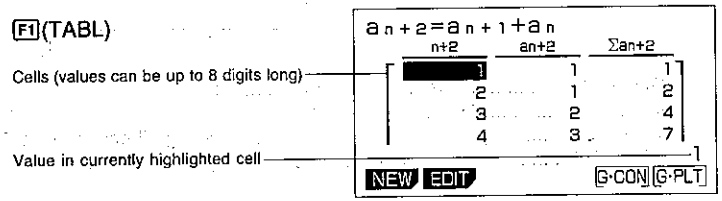
Input the range values.

[F6](a_1)
[1] [EXE] [6] [EXE] [1] [EXE] [1] [EXE]



Press [F1](TABL) to display the recursion table (consisting of each term and their sum). A menu of table functions also appears at the bottom of the display.

[F1](TABL)



•Each cell can hold up to eight digits if a value is positive, or seven digits if the value is negative. With exponential display, only two digits are allowed for the exponent.
•You can use the cursor keys to move the highlighting around the display.

Notes

•Only one table can be stored in memory at one time.
•When a negative, decimal, or fractional value is used for START or END, the negative value is converted to a positive value, and only the integer part of decimal and fractional values is used.
•When a_0 (or a_1) > START, the initial value of x-variable is changed so that it is the same as a_0 (or a_1).
•When START > END, the values of START and END are swapped.
•When START = END, only the initial value of x-variable is used.
•When START is a large value, a considerable amount of time may be required to generate a numeric table for linear recursion between two terms or three terms.
•When the n-data, a_n data, or Σa_n data causes an error in the calculation result, the message "Ma ERROR" appears on the display and a numeric table is not generated.

■Editing Table Data

The following editing functions can be performed on table data.

•Editing of the recursion formula
•Deletion of the recursion formula and input of a new one
•Drawing of a connected-point graph for the recursion table
•Drawing of plotted-point graph for the recursion table

• To start an editing operation

Use one of the two following procedures to start an editing operation. The procedure you use will depend on whether or not a recursion formula and table are already stored in memory.

- To edit a recursion formula already stored in memory, enter the Table & Graph Mode and then press [F1](FUNC) to display the recursion formula's table along with the table function menu.
- To edit a new recursion formula and table, first input the recursion formula. After you do, the table for the new recursion formula and the table function menu will appear on the display.

[F1](NEW) ..... Clears the formula for new input
[F2](EDIT) ..... For editing the formula
[F5](G·CON) ..... For drawing of a graph, connecting all points (page 255)
[F6](G·PLT) ..... For drawing of a graph, plotting all points without connecting them (page 255)

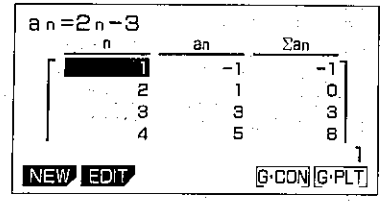
• To edit the recursion formula

Example **To change the formula from $a_n = 2_n + 1$ to $a_n = 2_n - 3$:**

[F2](EDIT)

◀◀−3

[F1](TABL)



- The table that appears shows values that are calculated using the new formula.

• To delete the formula and table data for new input

While the table function menu is displayed, press [F1](NEW).

[F1](NEW)

Press [F1](YES) to delete all the table's data and the formula, or [F6](NO) to abort the operation without deleting anything.

■Drawing a Graph Using Table Data

There are two types of graph you can draw using table data. A connected-point graph can be drawn using the formula stored in memory. A plotted-point graph can be drawn plotting only the points of the values in the table, without connecting them.

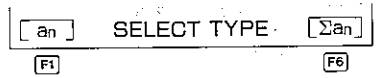
■Specifying the Y-Axis and X-Axis for the Graph

You specify either of the two following conditions for the x-axis and y-axis of the graph.

y-axis = a_n ; x-axis = n
y-axis = Σa_n ; x-axis = n

• To specify the x-axis and y-axis

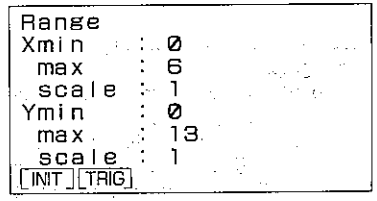
While the table function menu is shown, press [F5](G·CON) or [F6](G·PLT) to display the axis specification menu.



[F1](a_n) ..... y-axis = a_n ; x-axis = n
[F6](Σa_n) ..... y-axis = Σa_n ; x-axis = n

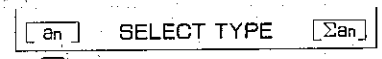
• To draw a connected-point graph

Example **To draw a connected-point graph of $a_n = 2_n + 1$ with y-axis = a_n and x-axis = n. Use the following range parameters:**



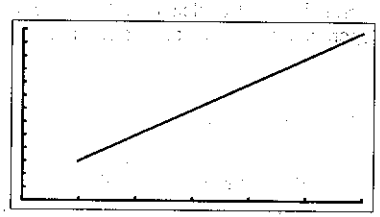
Specify a connected-point graph.

[F5](G·CON)



Specify the axes.

[F1](an)



• To draw a plotted-point graph

Example **To draw a plotted-point graph of $a_{n+2} = a_{n+1} + a_n$, with y-axis = Σa_n and x-axis = n. Use the following range parameters:**

```
Range
Xmin   : 0
 max   : 6
 scale : 1
Ymin   : 0
 max   : 20
 scale : 1
[INIT] [TRIG]
```

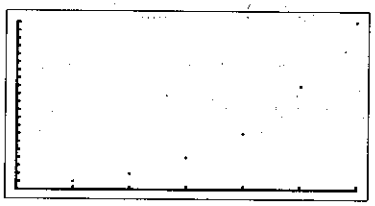
Specify plotted point graph.

[F6](G•PLT)

```
[an]   SELECT TYPE   [Σan]
                      F6
```

Specify the axes.

[F6](Σan)



- Use one of the two following procedures to input another recursion formula after drawing a graph.

  To edit the current recursion formula

  1. While the graph is on the display, press [G↔T] to return to the numeric table for the recursion formula that was used to draw the graph.
  2. Press [F2](EDIT) to make the cursor appear on the display.
  3. Use the procedures on page 254 to edit the recursion formula.

  To input a new recursion formula

  1. While the graph is on the display, press [G↔T] to return to the numeric table for the recursion formula that was used to draw the graph.
  2. Press [F1](NEW) and then [F1](YES) to delete the current recursion formula.
  3. Use the procedures on page 254 to input a new recursion formula.

- Once you draw a graph, you can use Trace, Zoom, Plot, Line and Scroll functions. See "8-12 Other Graph Functions" starting on page 185 for details.

Chapter 12

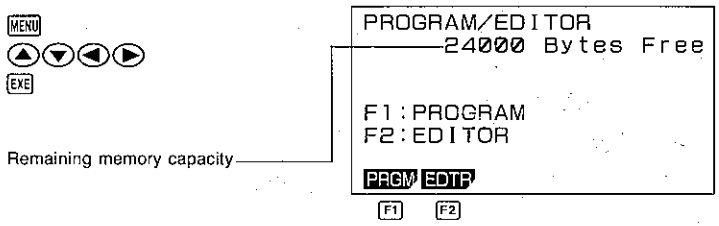
Program/File Editer Mode

Chapter 12 Program/File Editor Mode

This chapter tells you how to use the versatile Program Mode of the unit. Once you program a calculation, you can call it up and execute it using any values you want at the touch of a key.
This chapter also describes the File Editor Mode that you can use to input and edit large programs. You can also use the File Editor to edit and search telephone directory lists, memos, etc.

12-1 Before Using the Program/File Editor Mode

To use the Program/File Editor Mode, you should first select the **PRGM** icon from the Main Menu. When you do, the display shown here appears.



The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

F1(PRGM) ..... Program Mode
F2(EDTR) ..... File Editor Mode

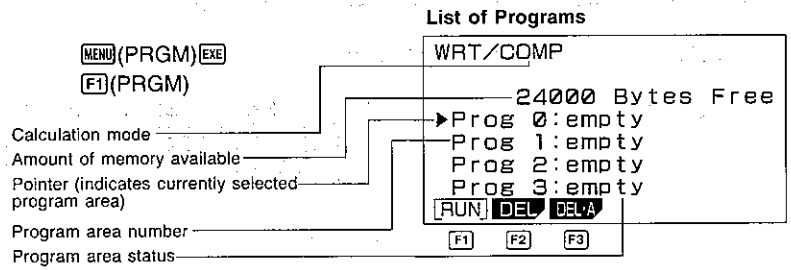
Note that you can use both the Program Mode and the File Editor Mode for program input and execution. How to use each of these modes most effectively is described in the following sections.

12-2 Using the Program Mode

This section explains how to use the Program Mode. We also provide a number of actual easy-to-understand examples for your reference.

■To Enter the Program Mode

Enter the Program Mode.



The above display shows that there are 24,000 bytes of memory available to store programs. Though you can see only four program area names, there are actually a total of 38, named Prog 0 through Prog 9, Prog A through Prog Z, Prog r, and Prog θ.
The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

F1(RUN) ..... Program execution
F2(DEL) ..... Specific program delete
F3(DEL·A) ..... All program delete

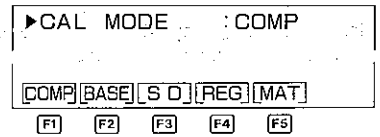
■Specifying the Calculation Mode

Before starting a programming operation, you should first specify the calculation mode (CAL MODE) that matches the calculation you plan to program. The mode you select determines the type of function key menu that appears on the bottom of the display.

• To specify the calculation mode

Perform the following operation while the list of programs is displayed.

SHIFT SETUP



The following are the calculation modes that can be selected from the function menu at the bottom of the display. Press the function key below the calculation mode you want to select.

F1(COMP) ..... Computation Mode
F2(BASE) ..... BASE Mode
F3(SD) ..... Standard Deviation Mode
F4(REG) ..... Regression Mode
F5(MAT) ..... Matrix Mode

*Pressing EXIT or SHIFT QUIT returns to the Program Mode.

■Selecting a Program Area

You can select a program area by moving the pointer to it using the ▲ and ▼ keys, or by directly inputting the number of letter that names the program area.

• To select a program area using the cursor keys

▼▼

```
     24000 Bytes Free
 Prog 0:empty
 Prog 1:empty
▶Prog 2:empty
```

• To select a program area using direct input

2

```
     24000 Bytes Free
▶Prog 2:empty
 Prog 3:empty
 Prog 4:empty
```

■Checking How Much Memory Is Used by a Program

You can check how much memory is used by a program either while the list of programs is displayed, or while you are inputting a program.

• Checking memory from the list of programs

1. Use the ▲ and ▼ keys to move the pointer to the program area whose memory status you want to check.
2. Hold down the [Bytes] key. The bottom line of the display shows the program area number and the number of bytes it contains.

• Checking memory while programming

Hold down the [Bytes] key. The bottom line of the display shows the current program area number and the number of bytes it contains.

```
Bytes P4-108
```

Program area number ↑ ↑ Number of bytes

■To Input a Program

Example **To program the following formulas, which calculate the surface area (S) and volume (V) of a regular octahedron when the length of one side (A) is known. Store program in area Prog 5.**

$S = 2\sqrt{3}A^2$ $V = \sqrt{2}/3A^3$

[MENU] (PRGM) [EXE]

▼▼▼▼▼

```
WRT/COMP
      24000 Bytes Free
 Prog 2:empty
 Prog 3:empty
 Prog 4:empty
▶Prog 5:empty
RUN DEL DEL-A
```

[EXE] (Starts programming)

```
_
```

[SHIFT] [PRGM] [F4] (?) → [ALPHA] [A] [F6] (:)
2 × [SHIFT] √ 3 × [ALPHA] [A] x^2
[F5] (◢)

```
?→A:2×√3×A²◢
_
```

JUMP REL Prog ? ◢ :

F4 F5 F6

[SHIFT] √ 2 ÷ 3 × [ALPHA] [A] ^ 3

[EXIT] [EXIT]

```
?→A:2×√3×A²◢
√2÷3×A^3_
```

*"?" is a prompt command for value input.
"◢" is a display result command.

■To Execute a Program Stored in Memory

Example **To execute the program stored by the operation described above, for A = 7, 10 and 15**

Length of one side	Surface area	Volume
7cm	(169.740979142)cm²	(161.691750631)cm³
10	(346.410161514)	(471.404520791)
15	(779.422863406)	(1590.99025767)

▼▼▼▼▼

```
WRT/COMP
      23980 Bytes Free
 Prog 2:empty
 Prog 3:empty
 Prog 4:empty
▶Prog 5:?→A:2×√3×A²◢
RUN DEL DEL-A
```

F1

[F1](RUN)

```
?
```

[7][EXE](Value of A)

```
?
7
                169.740979142
                    - Disp -
```

(S when A = 7)
"– Disp –" pauses calculation for display of result

[EXE]

```
?
7
                169.740979142
                161.691750631
```

(V when A = 7)

[EXE]

```
?
7
                169.740979142
                161.691750631
?
```

[1][0][EXE]
(Value of A)

```
7
                169.740979142
                161.691750631
?
10
                346.410161514
                    - Disp -
```

(S when A = 10)

[EXE]

```
7
                169.740979142
                161.691750631
?
10
                346.410161514
                471.404520791
```

(V when A = 10)

The remainder of the operation continues as described elsewhere, and so it is omitted here.

*If calculation is suspended to display a result, press [EXE] to resume the calculation.
*In the COMP Mode, you can also run a program by pressing [SHIFT][PRGM][F3](Prog), inputting the program area number, and pressing [EXE].
*When you execute a program, calculations are performed in the mode (COMP, BASE, SD, REG, MAT) that was selected when you input the program.

12-3 Deleting Programs

You can delete either individual programs or all of the programs stored in memory.

Important

The results of the procedures described below cannot be undone. Make sure that you do not need data any more before you delete it.

• To delete a specific program

Display the list of programs and move the pointer next to the program you want to delete.
Press [F2](DEL).

[F2](DEL)

```
[YES] DELETE PROGRAM [NO]
 F1                   F6
```

Press [F1](YES) to delete the program, or [F6](NO) to abort the operation without deleting anything.

• To delete all programs

Display the list of programs.
Press [F3](DEL·A).

[F3](DEL·A)

```
[YES] DELETE ALL PROGRAMS [NO]
 F1                       F6
```

Press [F1](YES) to delete all programs, or [F6] (NO) to abort the operation without deleting anything.

12-4 About Error Messages

Sometimes a program you enter causes an error message to appear when you execute it. This means that there is an error that needs to be corrected. The following shows a typical error message display

```
Syn  ERROR ———— Error type
Bytes P0-8 ———— Bytes where error occurred
           ———— Program area where error occurred
```

All of the possible error messages are listed in the Error Message Table on page 332
When you get an error message, look it up in the Error Message Table and take actions to correct it.

12-5 Counting the Number of Bytes

The memory of this unit can hold up to 24,000 bytes of data. Generally, one function in a program takes up one byte. Some functions, however, require two bytes each.

•1-byte functions
sin, cos, tan, log, (,), A, B, 1, 2, etc.

•2-byte functions
Lbl 1, Goto 2, Prog 3, etc.

You can count the bytes in a program by pressing the ◀ and ▶ keys. Each press of these keys causes the cursor to jump one byte. Display of the following is counted as two bytes:

- d/dx (, Σ(
- Mat, Det, Trn (in the MAT Mode)
- *Row, *Row +, Row +, Swap (in the PRGM-MAT Mode)
- Y, r, Xt, Yt, Sim X, Sim Y, Sim Z, Sim T, Sim U, Sim V, Sim Coef, Ply X_1, Ply X_2, Ply X_3, Ply Coef (in the VAR Mode)
- Xmin, Xmax, Xscl, Ymin, Ymax, Yscl, Tθmin, Tθmax, Tθptch, Xfct, Yfct, DTx, DTy, DTf (in the VAR Mode)
- F Result, F Start, F End, F Pitch, R Result, R Start, R End, R Pitch (in the VAR Mode)
- i, Arg, Conjg, Rep, ImP (in the CMPLX Mode)
- a_n, a_{n+1}, a_{n+2}, n, a_0, a_1 (in the TABLE-RECR Mode)

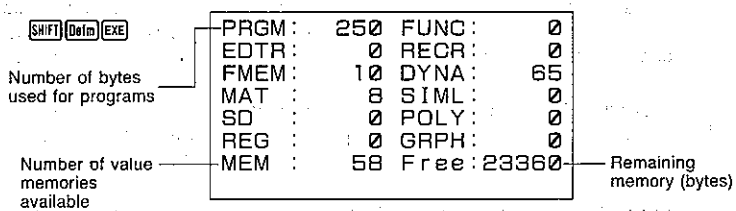
When the number of bytes remaining drops to five or below, the cursor automatically changes from an underline to "■". If you need to input more than five bytes, try to increase the amount of memory available for program storage by deleting unnecessary programs, deleting expanded memory, or by deleting unneeded function memory contents.

■To Check the Amount of Memory Remaining

[SHIFT][CAPA](Hold Down)

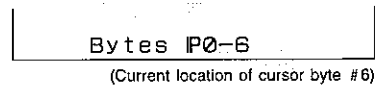
You can also display the remaining memory display by performing the following operation while the COMP, BASE, SD, REG or MAT Modes are displayed.

[SHIFT][Defm][EXE]



■To Check Where the Cursor Is Currently Located

[Mdisp]



(Current location of cursor byte #6)

The above screen remains on the display as long as [Mdisp] is depressed.

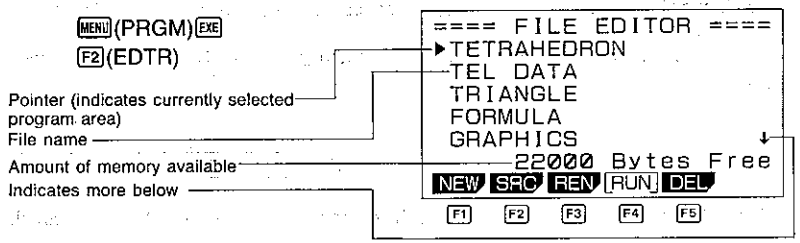
12-6 Using the File Editor Mode

This section explains how to use the File Editor Mode, which you can use to input programs as file data. You can store multiple files in memory, and you can conduct searches throughout a program's contents.
The File Editor Mode is also helpful for inputting and editing other, non-program data, such as telephone numbers, formulas, etc.

■To Enter the File Editor Mode

Enter the File Editor Mode.

[MENU](PRGM)[EXE]
[F2](EDTR)



Though you can see only four file names, the small downward pointing arrow on the right side of the display indicates that there are more file names below.

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

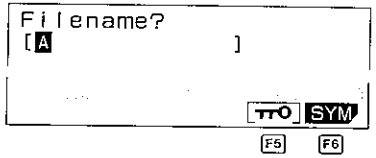
[F1](NEW) ..... New file
[F2](SRC) ..... Search
[F3](REN) ..... File name change
[F4](RUN) ..... Program execution
[F5](DEL) ..... File delete

•Whenever File Editor memory is empty (no files stored), the message "No File in Memory" appears on the display in place of the file name list. In this case, only the "NEW" function key menu item is available.

• To create a new file

After entering the File Editor Mode, press [F1](NEW).

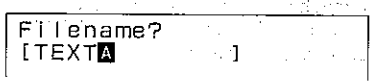
[F1](NEW)



[F5](TTO) ..... Password registration (page 267)
[F6](SYM) ..... Menu of punctuation symbols

Input the name of the file.

[T][E][X][T]



- The A cursor indicates upper-case alpha character input.
- A file name can be up to 12 characters long. You can use any of the following characters to make up a file name:
  A through Z, r, θ, spaces, 0 through 9, square brackets, ~, apostrophe, quotation marks, +, −, ×, ÷.
- To input apostrophes, quotation marks or ~, press [F6](SYM) to display a menu of these symbols.

[F6](SYM)

- To delete a character, move the cursor to the character you want to delete and press [DEL].

After you input the file name, press [EXE] to register it and change to the data input display.

[EXE]

- Each file name takes up 17 bytes of memory.
- Nothing happens if you press [EXE] without inputting a file name.
- Pressing [EXIT] before you input a file name returns to the File Editor display.

Input the data. For full details on data input procedures, see page 268.
- Pressing [EXIT] or [SHIFT][QUIT] returns to the File Editor display.

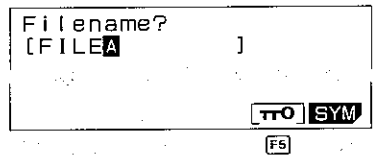
■Password Protection

You can register passwords to protect files. Once you do, no one can open the file unless they first input the correct password. Note that programs protected by a password can be executed without inputting the password.

• To create a file with a password

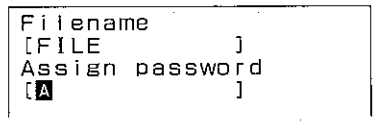
After entering the File Editor Mode, create a new file.

[F1](NEW)
[F][I][L][E]



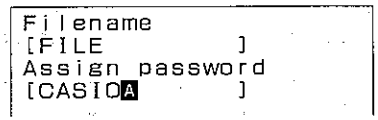
Press [F5](TTO).

[F5](TTO)



Input the password you want to use.

[C][A][S][I][O]



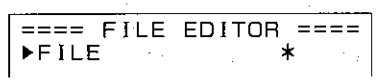
- The rules for input of a file name (page 266) also apply to input of the password.

After you input the file name, press [EXE] to register it and change to the data input display.
- Each password takes up 16 bytes of memory.
- No password is registered if you press [EXE] without inputting a password.
- Pressing [EXIT] before you input a password returns to the File Editor display.

Input the data. For full details on data input procedures, see page 268.

Press [EXIT] to return to the File Editor display. Files that are password protected are marked with an asterisk in the file name list.

[EXIT]



• To open a file

After entering the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the name of the file you want to open.

Press [EXE].

[EXE]

```
Filename
[FILE          ]
Password?
[A             ]
```

If the file is password protected, input the correct password and press [EXE] to open the file.

•If you input the wrong password, the message "Mismatch" appears. The following shows what happens if you input "KASIO" for a files whose password is "CASIO".

[K][A][S][I][O]
[EXE]

```
Filename
[FILE          ]
Password?
[KASIO         ]
 Mismatch
```

■Inputting Data into a File

You can input text, symbol, and operator data by pressing the keys of the unit. For symbols that are not included on the keys, use the symbol input menu (page 269). You can input any of the following as data: program commands, upper-case and lower-case alpha characters, numbers 0 through 9, decimal points, functions, operator symbols, and input symbols.

```
A

[TOP][BTM][SRC]        SYM
 F1   F2   F3          F6
```

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to select.

- [F1](TOP) ..... Cursor to top of data
- [F2](BTM) ..... Cursor to bottom of data
- [F3](SRC) ..... Data search
- [F6](SYM) ..... Symbol input data

For any individual file, you can input data up to the total memory capacity available.

■Inputting Program Commands

Input program commands using the same procedures that you use for writing programs. For details, see "To Input a Program" on page 260 and "12-7 Program Commands" on page 278.

■Inputting Upper-Case and Lower-Case Alpha Characters

Whenever you first enter the data input display, the unit is set up for upper-case alpha characters. This is indicated by the cursor which appears as A. Use the following procedures to input lower-case alpha characters, numbers, and symbols.

• To input lower-case alpha characters

Press [SHIFT] to switch to lower-case input. The keyboard remains shifted until you press [SHIFT] again.

• To input numbers and symbols

Press [ALPHA].

The following table shows how the cursor changes to indicate the type of input that is currently possible.

Cursor	Meaning
A	Upper-case alpha characters
a	Lower-case alpha characters
—	Standard numbers and operator symbols
S	[SHIFT] numbers and operator symbols

■Inputting Symbols

While the data input display is shown, press [F6](SYM) to display a menu of six symbols that are not available with the keys.

[F6](SYM)

```
 ·   "   ~   *   /   #
F1  F2  F3  F4  F5  F6
```

The following examples show how to input programs using the File Editor Mode.

Example 1 **Input the program of the following formulas in a file named TETRAHEDRON.**

$S = \sqrt{3}A^2 \quad V = \sqrt{2}/12A^3$

[F1](NEW)
[T][E][T][R][A][H][E][D][R][O][N]

```
Filename?
[TETRAHEDRONA]
```

[EXE]

```
A
```

[ALPHA][SHIFT][PRGM][F4](?)[→][ALPHA][A]
[F6](:)[ALPHA][SHIFT][√][3][x²]
[ALPHA][A][ALPHA][x²][F5](◢)

```
?→A:√3xA²◢
_
JUMP REL Prog ? ◢ :
 F4   F5   F6
```

[SHIFT][√][2][÷][1][2][x²][ALPHA][A]
[ALPHA][^][3]

```
?→A:√3xA²◢
√2÷12xA^3_
```

[EXIT][EXIT]

```
==== FILE EDITOR ====
▶TETRAHEDRON
```

Example 2 **Input the following name and telephone number data into a file named TEL DATA.**

Name	Telephone Number
AOKI KAZUO	03-3012-3456
ANDERSON JACK	234-228-8333
BENSON THOMAS	631-343-8888
BUSH KAREN	234-228-9199

[F1](NEW)
[T][E][L][SPACE][D][A][T][A]

```
Filename?
[TEL DATA■    ]
```

[EXE]

```
■
```

[A][O][K][I][SPACE][K][A][Z][U][O]
[EXE][SPACE][SPACE][SPACE][ALPHA][0][3][(-)]
[3][0][1][2][(-)][3][4][5][6][EXE]

```
AOKI KAZUO↵
   03-3012-3456↵
_
```


■Executing a Program

Use the following procedures to recall and execute programs stored as file data.

• To execute a program while in the File Editor Mode

In the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the name of the program you want to execute.

```
==== FILE EDITOR ====
▶TETRAHEDRON
 TEL DATA
 TRIANGLE
 FORMULA
 GRAPHICS                ↓
      22000 Bytes Free
NEW SRC REN RUN DEL
              F4
```

- If there are more than five files in memory, moving the pointer past the fifth name on the display causes the file name list to scroll.
- You can execute programs that are password protected without entering the password.

Press [F4](RUN) to execute the program where the pointer is located.

[F4](RUN)

```
?
```

[7][EXE]

```
?
7
                84.8704895709
                  - Disp -
```

[EXE]

```
?
7
                84.8704895709
                40.4229376578
```

The remainder of the operation continues as described elsewhere, and so it is omitted here.

- After program execution is complete, the menu for the calculation mode used for the programming appears on the display. If you want to use the File Editor again, you must enter the File Editor Mode again.
- If an error is generated while a program is executing, press ◀ or ▶ to display the contents of the program, with the cursor located at the point where the error was generated. Note that you will not be able to display the contents of the program if it is password protected.
- A "Syn ERROR" will occur if you perform the above program execution operation on a file that does not contain a program.

• To execute a program while outside of the File Editor Mode

Even if you are not in the File Editor Mode, you can use the following procedure to execute a program.

Example **To execute a program in a file named TETRAHEDRON.**

[SHIFT][PRGM][F3](Prog)

```
Prog _
```

[SHIFT][CHAR][F2](")[T][E][T][R][A][H][E][D][R][O][N][F2](")

```
Prog "TETRAHEDRON"
```

[EXE]

```
Prog "TETRAHEDRON"
?
```

The remainder of the operation continues as described elsewhere, and so it is omitted here.

■Checking the Memory Used by a Program

Use the following procedure to find out how much memory is used up by a program.

• To check the memory used by a file

In the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the name of the file you want to check.

Hold down the [M-Disp] to display the number of bytes used. The number of bytes used remains on the display as long as you keep [M-Disp] depressed.

[M-Disp]

```
EDITOR
G-type  :RECT /CONNECT
angle   :Deg
display :Norml
M-D/Cpy :M-Disp
[TETRAHEDRON ]

    Bytes     19
```

File name

Number of bytes

■Searching for Files

There are three different methods that you can use to search for a specific file name and open the corresponding file.

- **Direct input of the file name**
- **Sequential search using the file name list**
- **Direct search for a file name that starts with specific letters**

• To search for a file by directly inputting its file name

While in the File Editor Mode, press [F1](NEW).

[F1](NEW)

```
Filename?
[A                ]
```

Input the name of the file you want to open.

[T][E][T][R][A][H][E][D][R][O][N]

```
Filename?
[TETRAHEDRONA]
```

- If the file whose name you input is protected by a password, the password input display appears. For details on how to input the password, see "Password Protection" on page 267.

Press [EXE] to display the contents of the file.

[EXE]

```
?→A:√(3xA²)
√(2÷12xA^3
```

- If there is no file name that matches the one you input, a new file is opened under that file name.

• To sequentially search for a file using the file name list

In the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the name of the file you want to open.

[F2](EDTR)

```
==== FILE EDITOR ====
▶TETRAHEDRON
 TEL DATA
 TRIANGLE
 FORMULA
 GRAPHICS              ↓
      22000 Bytes Free
NEW SRC REN RUN DEL
```

Press [EXE] to open the file.

• To directly search for a file name that starts with specific letters

In the File Editor Mode, press [F2](SRC) to display the search prompt.

[F2](SRC)

```
Search for file
[A                ]
```

Input the first few letters of the name of the file you want to open.

[T][E]

```
Search for file
[TEA          ]
```

Press [EXE] to display a list of files whose names match your input.

[EXE]

```
==== FILE EDITOR ====
▶TETRAHEDRON
 TEL DATA


        22000 Bytes Free
NEW SRC REN RUN DEL
```

- All of the file names that start with the letters you specified appear on the display. If there are more than five files found, moving the pointer past the fifth name on the display causes the file name list to scroll.
- If none of the file names in memory start with the letters you specify, the message "Not found file!" appears on the display. Press [EXIT] to clear this message.

Use the [▲] and [▼] cursor keys to move the pointer to the left of the name of the file you want to open, and then press [EXE] to open it.

■Searching for Data in a File

The following procedures show how to find specific data inside of a file. The data search always starts from the current cursor location and continues until the end of the file is reached.

• To search for data in a file

Open the file whose contents you want to search, and then press [F3](SRC).

[F3](SRC)

```
Search for data

Input data
----------------------
A
----------------------
                    SYM
```


Input the string of characters that you want to search for.

[K][A]

```
Input data
----------------------
KAA
----------------------
```

- You can input a characters string that contains up to 127 bytes as the search string.
- You cannot specify newline (↵) and display (◢) commands in the search string.

Press [EXE] to start the search. A display of data appears with the cursor located at the first occurrence of the characters you specified. The <Search> indicator at the bottom of the display indicates that a search operation is in progress.

[EXE]

```
AOKI KAZUO↵
    03-3012-3456↵
ANDERSON JACK↵
    234-228-8333↵
BENSON THOMAS↵
    631-343-8888↵
BUSH KAREN↵
     <Search>      SYM
```

*This display shows the contents of the file named TEL DATA.

Each time you press [EXE], the cursor jumps to the next occurrence of the characters you specified.

[EXE]

```
AOKI KAZUO↵
    03-3012-3456↵
ANDERSON JACK↵
    234-228-8333↵
BENSON THOMAS↵
    631-343-8888↵
BUSH KAREN↵
     <Search>      SYM
```

- If there are no occurrences of the letters you specify, the data display appears without any cursor or <Search> indicator.
- After you find the data you want, you can input characters to edit the data or you can use the cursor keys to move the cursor. Doing so automatically exits the search operation (causing the <Search> indicator to disappear from the display).

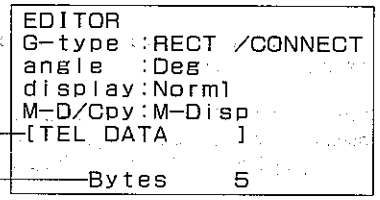
• To check the current cursor location

Use the cursor keys to move the cursor to the location that you want to check.

Hold down the [Disp] key. The current cursor location is shown on the display as long as you keep [Disp] depressed.

•Remember that you must press [ALPHA] before [Disp] if the cursor indicates alpha character input.

[Disp]



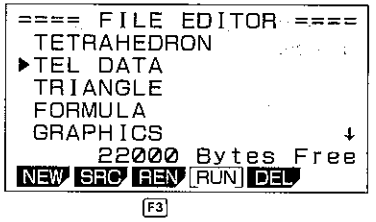
■Editing File Data

The following procedures can be used to modify and delete data stored in files.

• To change a file name

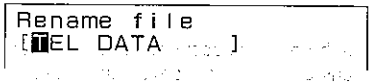
In the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the file whose name you want to change.

[F2](EDTR)▼



Press [F3](REN) for the file renaming display.

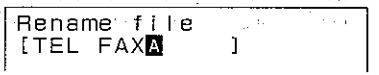
[F3](REN)



Make the changes to the file name that you want.

▶▶▶▶

[DEL][DEL][DEL][DEL][F][A][X]



After you change the name, press [EXE] to store the file under its new name and return to the File Editor Mode.

•If the new file name is identical to a file name that is already used, the message "Already exists" appears on the display. When this happens, perform one of the following procedures.

•Press the ◀ or ▶ cursor keys to clear the error and return to the file renaming display with the new file name. Make any changes you want and then press [EXE] again.

•Press [AC] to clear the new file name and return to the file renaming display. Input a different name and then press [EXE] again.

• To delete a file

1. In the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the file you want to delete.

2. Press [F5](DEL).

[F5](DEL)

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

• To modify, insert, and delete file data

1. In the File Editor Mode, use the ▲ and ▼ cursor keys to move the pointer to the left of the file whose data you want to edit.
2. Press [EXE] to display the data contained in the file.
3. Edit the data using the same procedures described for manual calculations under "Editing Calculations" on page 29.

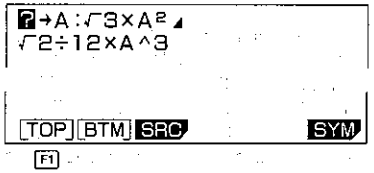
■Other Useful Cursor Movement Functions

The following functions also come in handy when moving the cursor around inside a file.

[F1](TOP) ..... Moves the cursor to the top of the data.

Example

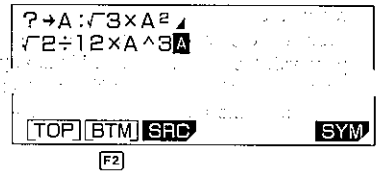
[F1](TOP)



[F2](BTM) ..... Moves the cursor to the end of the data.

Example

[F2](BTM)



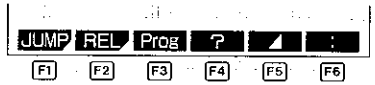
12-7 Program Commands

The unit provides you with special programming commands that let you perform conditional and unconditional jumps and loops.

•All of the explanations provided here are performed using the Program Mode only. Note, however, that you can also perform the same operations in the File Editor Mode.

■To Display the Program Function Menu

[SHIFT] [PRGM]



The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

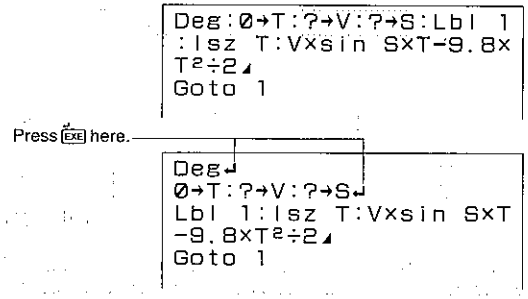
[F1](JUMP) ..... Displays jump command menu
[F2](REL) ..... Displays relational operator menu
[F3](Prog) ..... Inputs "Prog" for program area specification
[F4](?) ..... Prompt command for value input
[F5](◢) ..... Display result command
[F6](:) ..... Multistatement connector

•The input in response to a prompt command "?" can be a value or calculation expression up to 111 bytes long. No non-calculation command or multistatement can be performed while the calculator is waiting for input in response to a prompt command.
•The display result command "◢"causes program execution to stop while the calculation result up to the display result command or a text message is displayed. To resume program execution, press [EXE]. The final result of the program execution is displayed regardless of whether or not this command is included at the end. Note, however, that this command should be used at the end of the BASE Mode program in order to return the unit to its original mode following the program.

•The multistatement connector ":" is used to connect two or more statements together for sequential execution. Unlike statements connected by the display result command, statements connected by the multistatement connector are executed from beginning to end, non-stop. Note that you can also use the Newline Function (described below) to connect statements, and make them easier to read on the display.

■About the Newline Function

The Newline Function is a multistatement connector that, performs a newline operation instead of inserting a ":" symbol at the connection of two statements.
Note the two following displays.



Both displays show the same programs, except that the upper one uses multistatements commands, while the lower one uses the Newline Function. Note how much easier the lower display is to read.

• To use the Newline Function

To perform a newline operation at the end of a statement, press [EXE].

■To Display the Jump Command Menu

[SHIFT] [PRGM] [F1](JUMP)

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1](⇒) ..... Indicates conditional jump destination
[F2](Goto) ..... Indicates unconditional jump destination
[F3](Lbl) ..... Indicates label
[F4](Dsz) ..... Decrements value memory
[F5](Isz) ..... Increments value memory

■To Display the Relational Operator Menu

[SHIFT] [PRGM] [F2] (REL)

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1] (=) ..... Equal
[F2] (≠) ..... Not equal
[F3] (>) ..... Greater than
[F4] (<) ..... Less than
[F5] (≥) ..... Greater than or equal to
[F6] (≤) ..... Less than or equal to

■To display the Punctuation Symbol Menu

[ALPHA]

The following are the operations that are available from the function display at the bottom of the screen. Press the function key below the operation you want to perform.

[F1] (') ..... Start of non-executable remarks
[F2] (") ..... Indicates display text
[F3] (~) ..... Indicates range of value memories

- The single quotation mark indicates the beginning of non-executable remarks. It is useful to insert a program name at the beginning of the program for display in the program area list (only the first 12 characters are displayed). The unit considers anything from a single quotation mark up to the next multistatement connector (:), display result command (◢), or newline operation to be part of the remarks. Remarks can contain letters or numbers.
- Double quotation marks indicate text to be shown on the display. Display text can contain letters or numbers. The unit considers anything from a double quotation mark up to the next multistatement connector (:), display result command (◢), or newline operation to be part of the display text. Display text can contain letters or numbers.
- The "~" symbol is used to indicate a range of value memories. For example, to assign a value of 10 to value memories A through F, you would specify the following:

10 → A~F ([1] [0] [→] [ALPHA] [A] [ALPHA] [F3] (~) [ALPHA] [F])

This symbol cannot be used to assign values to value memories r or θ, but it can be used with array memories (page 285). It is most useful when you want to clear a series of value memories by assigning them with a value of zero in a program.

12-8 Using Jump Commands

Generally, programs are executed from beginning to end, in the order that they are input into memory. This can cause problems when you want to repeat an operation a number of times or when you want to execute a formula in a different location. Jump commands make it possible to accomplish such operations very easily.

■About Unconditional Jumps

An unconditional jump is one that is performed no matter what circumstances exist. To use an unconditional jump with the unit, you first identify the destination of the jump with a label. Then you tell the unit at some point to go to the label and continue execution of the program.

To illustrate, we will reprogram the calculation for the surface area and volume of a regular octahedron that we originally wrote on page 260. With our previous program, we had to start the program three different times to perform our calculations. With an unconditional jump however, once we start program execution, it repeats until we tell it to stop.

• To use an unconditional jump

Example **To program the formula $y = Ax + B$, so that for each execution the values of A and B remain constant, but the value of x varies.**

Program

?, →, A, :, ?, →, B, :, Lbl 1, :, ?, →, X, :, A, ×, X, +, B, ◢, Goto 1 23 bytes

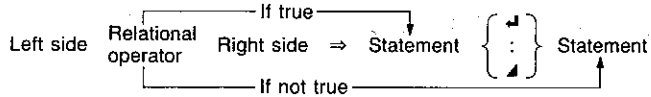
With this program, a prompt appears once for A and B. A prompt for X appears with each execution, of the loop back to label 1 (Lbl 1).

Note

*If your program tells the calculator to go to a label that does not exist, an error message (Go ERROR) appears on the display.

■About Conditional Jumps

With a conditional jump you set up certain criteria and control whether or not the jump is actually performed. Look at the following format.



As shown above, if the condition defined by the relational operator is true, the statement following "⇒" is executed, and then the next statement is executed. If the condition is false, the statement following "⇒" is skipped.
The following are the conditions that you can define using the relational operators.

L=R ..... True when L and R are equal; false when L and R are not equal
L≠R ..... True when L and R are not equal; false when L and R are equal
L>R ..... True when L is greater than R; false when L is less than or equal to R
L<R ..... True when L is less than R; false when L is greater than or equal to R
L≥R ..... True when L is greater than or equal to R; false when L is less than R
L≤R ..... True when L is less than or equal to R; false when L is greater than R

• To use a conditional jump

Example 1 **To write a program that calculates the square root of any input value that is greater than or equal to zero. If a value that is less that zero is input, the program ignores it and prompts further input.**

Program

Lbl, 1, :, ?, →, A, :, A, ≥, 0, ⇒, √, A, ◢, Goto, 1 16 bytes

This program starts out by prompting input for A. The next statement tests the input by saying: "if the value of A is greater than or equal to 0, then calculate the square root of A". This is followed by a display result command. After the result is displayed, pressing [EXE] continues with the Goto 1 unconditional jump to label 1 (Lbl 1) at the beginning of the program. For values that are less than 0, the square root calculation statement is skipped and execution jumps directly to the Goto 1 statement.

Example 2 **To write a program that accumulates input values, but displays the total of the values any time zero is entered.**

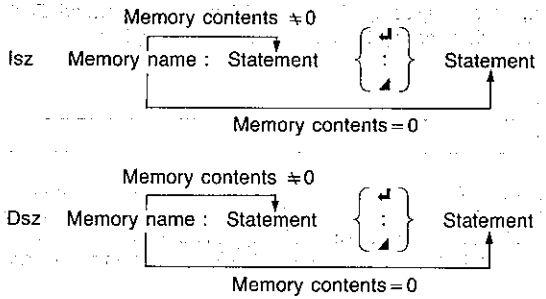
Program

0, →, B, :,
Lbl, 1, :, ?, →, A, :, A, =, 0, ⇒, Goto, 2, :,
A, +, B, →, B, :, Goto, 1, :,
Lbl, 2, :, B 31 bytes

With this program, 0 is assigned to value memory B to clear it. The next statement prompts for input of a value to value memory A. The next statement is a conditional jump that says: "if the value input for A equals 0, then go to label 2". The statement following label 2 (Lbl 2) ends program execution with a display of the value memory B contents. For other values, the next statement adds value memories A and B, and then stores the result in value memory B again. After this, program execution returns to the statement following label 1 (Lbl 1), where the next input for A is prompted.

■ About Count Jumps

There are two count jumps: one that increments a value memory (Isz) and one that decrements a value memory (Dsz). Look at the following format.



As shown above, if the increment or decrement operation does not cause the content of the value memory to become 0, the statement following the value memory name is executed. If the content of the value memory becomes 0, the next statement is skipped.

• To use a count jump

Example 1 **To write a program that accepts input of 10 values, and then calculates the average of the values.**

Program

1, 0, →, A, :, 0, →, C, :,
Lbl, 1, :, ?, →, B, :, B, +, C, →, C, :,
Dsz, A, :, Goto, 1, :, C, ÷, 1, 0 32 bytes

This program starts out by assigning a value of 10 to A. This is because value memory A will be used as a control variable. The next statement clears C to zero. After defining the location of label 1 (Lbl 1), the program then prompts for input of a value for B. The next statement adds the value of B to value memory C, and then stores the result in C. The next three statements say: "decrement the value in A, and if it is still greater than 0, jump back to label 1; otherwise divide the contents of C by 10".

Example 2 **To write a program that calculates at 1-second intervals the altitude of a ball thrown into the air at an initial velocity of Vm/sec and an angle of S°. The formula is expressed as: $h = V \cdot \sin St - \frac{1}{2}gt^2$, with $g = 9.8$. The effects of air resistance should be disregarded.**

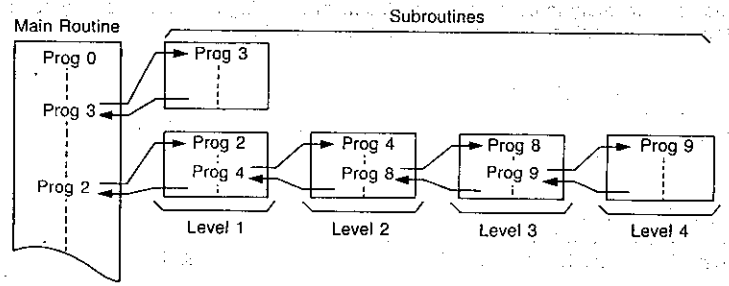
Program

Deg, :, 0, →, T, :, ?, →, V, :, ?, →, S, :,
Lbl, 1, :, Isz, T, :, V, ×, sin, S, ×, T, −,
9, ·, 8, ×, T, x^2, ÷, 2, ◢, Goto, 1 38 bytes

With this program, the first statements specify the unit of angular measurement and clear T to 0. Then the initial velocity is prompted for V and the angle is prompted for S. Lbl 1 identifies the beginning of the repeat calculation.
The value stored in T is incremented by Isz T, and in this program the Isz command is used only for incrementation, without any comparison or decision being performed. Each time T is incremented, the formula is calculated and the altitude is displayed.

12-9 Using Subroutines

Up to this point, all of the programs we have seen were contained in a single program area. You can also jump between program areas, so that the resulting execution is made up of pieces in different areas. In such a case, the central program from which other areas are jumped to is called a "main routine". The areas jumped to from the main routine are called "subroutines".
Note that you can use either another program stored in the program area or a program stored as a File Editor file as a subroutine.



To jump to a subroutine, use Prog (input using [SHIFT][PRGM][F3](Prog)) followed by a program area name (0 to 9, A to Z, r, or θ) or the name of a File Editor file.

Examples **Prog 2 — Jumps to the program stored in program area number 2.**
Prog ABC — Jumps to the program stored in a file named "ABC".

After the jump to the program you specify, execution continues from the beginning of the subroutine. When end of the subroutine is reached, execution returns to the statement following the Prog command that initiated the subroutine.
You can jump from one subroutine to another, a procedure that is called "nesting". You can nest up to a maximum of 10 levels, and an error will occur (Ne ERROR) if you try to nest an 11th time. If you try to jump to a program area that does not contain a program, an error message (Go ERROR) will appear on the display.

Important

- The Goto command does not jump between program areas. A Goto command jumps to the label (Lbl) located inside the same program area.

■Subroutines Save Memory

Note the following two programs.

Prog 0 Fix, 3, :, ?, →, A, :, 2, ×, √, 3, ×, A, x^2, ◢,
√, 2, ÷, 3, ×, A, ^, 3 — 23 bytes

Prog 1 Fix, 3, :, ?, →, A, :, √, 3, ×, A, x^2, ◢,
√, 2, ÷, 1, 2, ×, A, ^, 3 — 22 bytes

If we input these two programs separately, they require a total of 45 bytes. But note that the underlined portions of these two programs are identical. This means that these parts can be stored as subroutines and called by both of the programs.
If we use subroutines, we get the following results.

Subroutines

Prog 9 Fix, 3, :, ?, →, A, :, √, 3, ×, A, x^2 — 12 bytes
Prog 8 √, 2, ÷, 3, ×, A, ^, 3 — 8 bytes

Main routines

Prog 0 Prog, 9, :, Ans, ×, 2, ◢, Prog, 8 — 9 bytes
Prog 1 Prog, 9, ◢, Prog, 8, :, Ans, ÷, 4 — 9 bytes

As you can see, the number of bytes required to store the two programs and the subroutines is 38, for a saving of 7 bytes.
When you execute the program in program area 0, it immediately jumps to Prog 9 and executes the contents of that program area. At the end of Prog 9, execution returns to Prog 0 where the result produced by the subroutine in Prog 9 is multiplied by 2 and then displayed. After you press the [EXE] key, execution jumps to Prog 8, where the remainder of the program is executed.
With the main routine in program area Prog 1, execution jumps immediately to program area Prog 9. At the end of Prog 9 execution returns to Prog 1 where the Prog 9 result is displayed. When you press [EXE], execution jumps again to Prog 8. At the end of Prog 8, execution returns to Prog 1, where the result produced by Prog 8 is divided by 4 and displayed.

12-10 Using Array Memory

In addition to the individual value memories, the unit gives you array memory capabilities. Note the following.

Value Memories	Array Memories
A	A[0] B[−1]
B	A[1] B[0]
C	A[2] B[1]

Note

*You cannot use r or θ value memory as array memory.

As you can see, array memory names consist of an alphabetic character, followed by a *subscript* enclosed in brackets. The subscript is a value, either positive or negative, or a value memory that represents a value. If the value of 5 is assigned to value memory X, for example, the array memory A[X] would be equivalent to A[5].

■Array Memories Simplify Programming

Since the subscript of an array memory can be a value memory name, programming becomes more economical. Note the following.

Example **To write a program that assigns the values from 1 through 10 to memories A through J**

Using value memories

1, →, A, :, 2, →, B, :, 3, →, C, :, 4, →, D, :,
5, →, E, :, 6, →, F, :, 7, →, G, :, 8, →, H, :,
9, →, I, :, 1, 0, →, J — 40 bytes

Using array memories

0, →, Z, :, Lbl, 1, :, Z, +, 1, →, A, [, Z,], :,
Isz, Z, :, Z, <, 1, 0, ⇒, Goto, 1 — 26 bytes

As you can see, using array memories uses 14 fewer bytes. You get even more economy with the following program.

Example **To write a program that displays the contents of a memory specified by input**

Using value memories

Lbl, 1, :, ?, →, Z, :,
Z, =, 1, ⇒, A, ◢, Z, =, 2, ⇒, B, ◢,
Z, =, 3, ⇒, C, ◢, Z, =, 4, ⇒, D, ◢,
Z, =, 5, ⇒, E, ◢, Z, =, 6, ⇒, F, ◢,
Z, =, 7, ⇒, G, ◢, Z, =, 8, ⇒, H, ◢,
Z, =, 9, ⇒, I, ◢, Z, =, 1, 0, ⇒, J, ◢,
Goto, 1 — 70 bytes

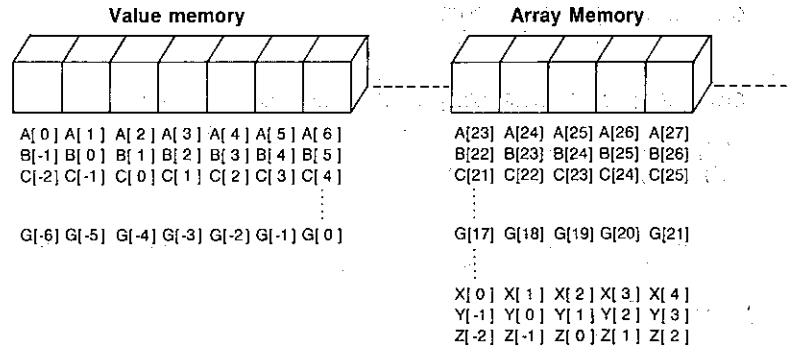
Using array memories

Lbl, 1, :, ?, →, Z, :, A, [, Z, −, 1,], ◢,
Goto, 1 — 16 bytes

With value memories, logical operations are used to test the input until the proper memory is found. With array memories, on the other hand, the specified memory is found immediately.

■Cautions When Using Array Memories

You should remember that array memories are actually based on value memories. Note the following relationship.



This means that you must be careful when using array memories that you do not overlap.

■Sample Programs That Use Array Memory

The following programs store *x* and *y* data in array memories. Whenever an *x* value is input, the corresponding *y* value is displayed. You can input a total of 15 sets of data.

Example 1 **With this version of the program, value memory A is used as a data control memory, while memory B is used for temporary storage of *x* data. The *x* data is stored in memories C[1] (value memory D) through C[15] (value memory R), while the *y* data is stored in memories C[16] (value memory S) through C[30] (value memory Z[7]).**

1, →, A, :, Defm, 7, :,
Lbl, 1, :, ?, →, C, [, A,], :,
?, →, C, [, A, +, 1, 5,], :,
Isz, A, :, A, =, 1, 6, ⇒, Goto, 2, :, Goto, 1, :,
Lbl, 2, :, 1, 5, →, A, :, ?, →, B, :,
B, =, 0, ⇒, Goto, 5, :,
Lbl, 3, :, B, =, C, [, A,], ⇒, Goto, 4, :,
Dsz, A, :, Goto, 3, :, Goto, 2, :,
Lbl, 4, :, C, [, A, +, 1, 5,], ◢, Goto, 2, :,
Lbl, 5 — 98 bytes

The above program uses value memories as follows:

x **data**

C[1]	C[2]	C[3]	C[4]	C[5]	C[6]	C[7]	C[8]	C[9]	C[10]
D	E	F	G	H	I	J	K	L	M
C[11]	C[12]	C[13]	C[14]	C[15]					
N	O	P	Q	R					

y **data**

C[16]	C[17]	C[18]	C[19]	C[20]	C[21]	C[22]	C[23]	C[24]	C[25]
S	T	U	V	W	X	Y	Z	Z(1)	Z(2)
C[26]	C[27]	C[28]	C[29]	C[30]					
Z(3)	Z(4)	Z(5)	Z(6)	Z(7)					

Example 2 **This version is identical to Example 1, except that a different letter is used for the *x* and *y* data names.**

```
1, →, A, :, Defm, 7, :,
Lbl, 1, :, ?, →, C, [, A, ], :,
?, →, R, [, A, ], :,
Isz, A, :, A, =, 1, 6, ⇒, Goto, 2, :, Goto, 1, :,
Lbl, 2, :, 1, 5, →, A, :, ?, →, B, :,
B; =, 0, ⇒, Goto, 5, :,
Lbl, 3, :, B, =, C, [, A, ], ⇒, Goto, 4, :,
Dsz, A, :, Goto, 3, :, Goto, 2, :,
Lbl, 4, :, R, [, A, ], ◢, Goto, 2, :,
Lbl, 5                                          92 bytes
```

This above program uses value memories as follows:

x **data**

C[1]	C[2]	C[3]	C[4]	C[5]	C[6]	C[7]	C[8]	C[9]	C[10]
D	E	F	G	H	I	J	K	L	M
C[11]	C[12]	C[13]	C[14]	C[15]					
N	O	P	Q	R					

y **data**

R[1]	R[2]	R[3]	R[4]	R[5]	R[6]	R[7]	R[8]	R[9]	R[10]
S	T	U	V	W	X	Y	Z	Z(1)	Z(2)
R[11]	R[12]	R[13]	R[14]	R[15]					
Z(3)	Z(4)	Z(5)	Z(6)	Z(7)					

Note that in the above two programs the Defm command was necessary to increase the number of value memories.

12-11 Displaying Text Messages

Text, numbers, and symbols can be displayed by programs as messages that prompt input, etc. Note the following example.

Statement	Display
Without text ? → X	?
With text "X=" ? → X	X=?

As you can see, the text prompt makes it much easier to understand what input is required by the program.

Messages can also be used to explain the meaning of a displayed result.

- All of the explanations provided here are performed using the Program Mode only. Note, however, that you can also perform the same operations in the File Editor Mode.

Example

```
Lbl, 0, :, ", N, =, ", ?, →, B, ~, C, :,
0, →, A, :,
Lbl, 1, :, C, ÷, 2, →, C, :, Frac, C, ≠, 0, ⇒, Goto, 3, :,
Isz, A, :, C, =, 1, ⇒, Goto, 2, :, Goto, 1, :,
Lbl, 2, :, ", X, =, ", ◢, A, ◢, Goto, 0, :,
Lbl, 3, :, ", N, O, ", ◢, Goto, 0                70 bytes
```

This program prompts for input of a value. If the input value is equivalent to 2^x, it displays the value of x. If the input value is not equivalent to 2^x, it displays the message "NO".

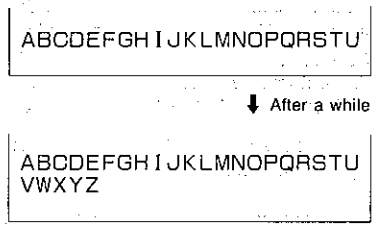
Important

Be sure to follow the message with a display result command if there is another statement following the message.

Assuming that the program is stored in Prog 2:

[F1](RUN)	N=?
[4][0][9][6][EXE]	X=
[EXE]	12
[EXE]	N=?
[3][1][2][4][EXE]	NO

Text that is longer than 21 characters is displayed in two lines. When text is at the bottom of the display, the entire screen scrolls upwards.



12-12 Using Matrices in Programs

You can use matrix row operations (page 118) in programs to swap rows, calculate scalar products, add scalar products to other rows, and add two rows.

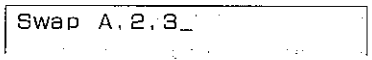
- All of the explanations provided here are performed using the Program Mode only. Note, however, that you can also perform the same operations in the File Editor Mode.

• To swap two rows

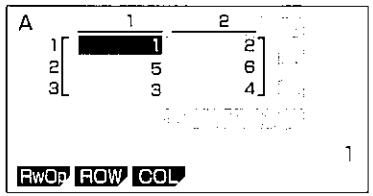
Example **To swap rows two and three in the following matrix (Matrix A).**

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

Swap, A, ', 2, ', 3 7 bytes



EXIT EXIT F1(RUN)
F5(SEE)

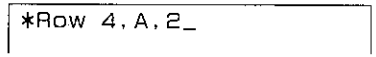


• To calculate a scalar product for a row

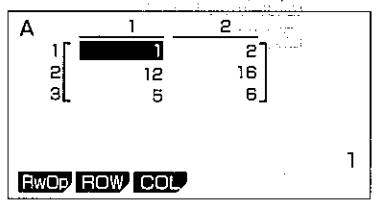
Example **To calculate a scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4.**

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

∗ Row, 4, ', A, ', 2 7 bytes



EXIT EXIT F1(RUN)
F5(SEE)

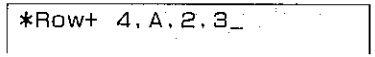


• To add the scalar product of one row to another row

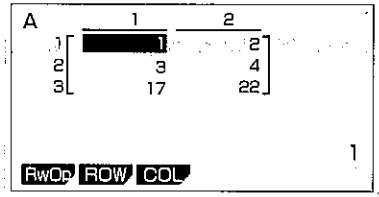
Example **To calculate a scalar product of row 2 of the following matrix (Matrix A), by multiplying each element by 4, and then add the results to row 3.**

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

∗ Row+, 4, ', A, ', 2, ', 3 9 bytes



EXIT EXIT F1(RUN)
F5(SEE)



• To add one row to another

Example **To add row 2 to row 3 in the following matrix (Matrix A), and store the result in row 3.**

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

Row+, A, ›, 2, ›, 3 — 7 bytes

```
Row+ A,2,3_
```

EXIT EXIT F1 (RUN)
F5 (SEE)

```
A      1      2
1 [    1      2 ]
2 [    3      4 ]
3 [    5     10 ]
                 1
RwOp ROW COL
```

12-13 Using the Graph Function in Programs

By using the graph function in programs, you can graphically represent long, complex equations and overdraw graphs a number of times. All graph commands (except the Trace Function) can be used in programs. You can also specify range parameters in programs.

- All of the explanations provided here are performed using the Program Mode only. Note, however, that you can also perform the same operations in the File Editor Mode.

Example **To graphically represent the number of solutions (real roots) that satisfy both of the following equations**

$y = x^4 - x^3 - 24x^2 + 4x + 80$
$y = 10x - 30$

Use the following range parameters.

Xmin	−10
max	10
scale	2
Ymin	−120
max	150
scale	50

First, program the range parameters. Note that parameters are separated by commas. Press EXE at the end.
Range, (−), 1, 0, ›, 1, 0, ›, 2, ›, (−), 1, 2, 0, ›, 1, 5, 0, ›, 5, 0

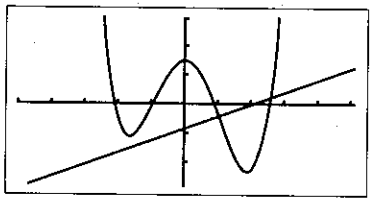
Next, program the equation for the first graph. Press EXE at the end.
Graph, X, ^, 4, −, X, ^, 3, −, 2, 4, X, x^2, +, 4, X, +, 8, 0

Finally, program the equation for the second graph.
Graph, 1, 0, X, −, 3, 0 — Total: 49 bytes

```
Range -10,10,2,-120,1
50,50↵
Graph Y=X^4-X^3-24X²+
4X+80↵
Graph Y=10X-30_
```

The above program should produce this graph when you execute it.

EXIT F1 (RUN)



You could use a display result command (◢) in place of the EXE operation at the end of the first equation. This will cause execution to stop after the first graph is drawn. To resume execution, press EXE.

Chapter 13

Data Communications

Chapter 13 Data Communications

This chapter tells you everything you need to know to transfer programs between the fx-9700GH and another CASIO Power Graphic unit (fx-7700GB, fx-7700GE, fx-7700GH, fx-8700GB, fx-9700GE, fx-9700GH), connected with an optionally available SB-62 cable. To transfer data between an fx-9700GH unit and a personal computer, you will need to purchase the separately available CASIO FA-121 Ver. 2.0 Interface Unit.
This chapter also contains information on how to use the optional SB-62 cable to connect to a CASIO Label Printer to transfer screen data for printing.

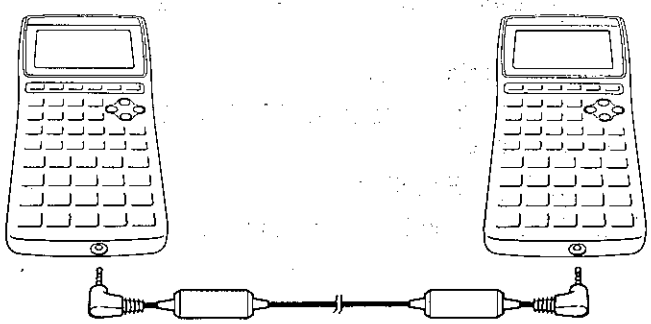
•Though you can transfer programs between the fx-9700GH and another fx-9700GH, an fx-7700GB, an fx-7700GE, an fx-7700GH, an fx-8700GB or fx-9700GE, all of the examples in this manual cover data transfer with another fx-9700GH only.

13-1 Connecting Two fx-9700GH Units

The following procedure describes how to connect two Power Graphic units with an optional SB-62 connecting cable for transfer of programs between them.

■To Connect Two fx-9700GH Units

1. Check to make sure that the power of both fx-9700GH units is off.
2. Remove the covers from the connectors of the two Power Graphic units.
   •Be sure you keep the connector covers in a safe place so you can replace them after you finish your data communications.
3. Connect the two units using the SB-62 cable.



SB-62 cable

Important

•Keep the connectors of the fx-9700GH covered when you are not using them.

13-2 Connecting the fx-9700GH with a Personal Computer

To transfer data between the fx-9700GH and a personal computer, you must connect them through a separately available CASIO FA-121 Ver. 2.0 Interface Unit.

For details on operation, the types of computer that can be connected, and handware limitations, see the user's manual that comes with the FA-121 Ver. 2.0.

■To Connect the fx-9700GH with a Personal Computer

1. Check to make sure that the power of the Power Graphic and the personal computer is off.
2. Connect the personal computer to the FA-121 Ver. 2.0 Interface Unit.
3. Remove the cover from the connector of the fx-9700GH.
   •Be sure you keep the connector cover in a safe place so you can replace it after you finish your data communications.
4. Connect the fx-9700GH to the FA-121 Ver. 2.0 Interface Unit.
5. Switch on the power of the fx-9700GH, followed by the personal computer.
   •After you finish data communications, switch off power in the sequence: fx-9700GH first, and then the personal computer. Finally, disconnect the equipment.

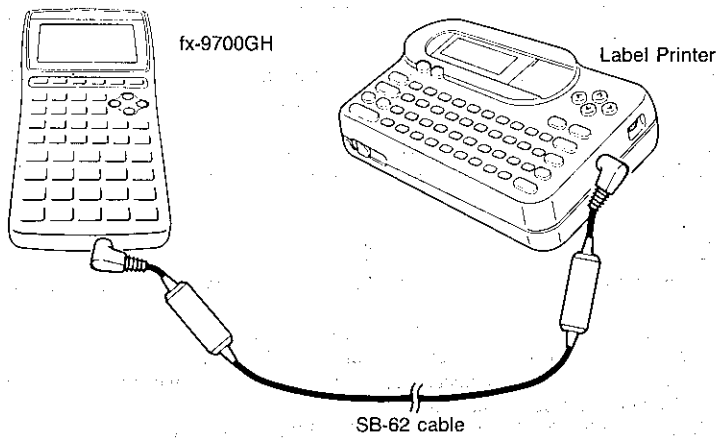
13-3 Connecting the fx-9700GH to a CASIO Label Printer

After you connect the fx-9700GH to a CASIO Label Printer with an optional SB-62 cable, you can use the Label Printer to print screen shot data from the fx-9700GH. See the User's Manual that comes with your Label Printer for details on how to perform this operation.

•The operation described above can be performed using the following Label Printer models: KL-2000, KL-2700 (as of December 1994)

■To connect the fx-9700GH with a Label Printer

1. Check to make sure that the power of the Power Graphic and the Label Printer is off.
2. Connect the optional SB-62 cable to the Label Printer.
3. Remove the cover from the connector of the fx-9700GH.
   •Be sure you keep the connector cover in a safe place so you can replace it after you finish your data communications.
4. Connect the other end of the SB-62 cable to the fx-9700GH.
5. Switch on the power of the fx-9700GH, followed by the Label Printer.



•After you finish data communications, switch off power in the sequence: fx-9700GH first, and then the Label Printer. Finally, disconnect the equipment.

13-4 Before Starting Data Communications

Before actually starting data communications, you should first enter the LINK Mode from the Main Menu.

■To Enter the LINK Mode

Highlight the **LINK** icon on the Main Menu.

[MENU]

[▲][▼][◀][▶]

Press [EXE] to display the LINK Mode.

[EXE]

```
COMMUNICATION

 PARITY:EVEN
 BPS    :9600
F1:TRANSMIT
F2:RECEIVE
F6:PARAMETERS
TRN RCV        PRM
```

[F1] [F2] [F6]

The following are the operations that can be selected from the function menu at the bottom of the display. Press the function key below the operation you want to perform.

[F1](TRN) ..... Transmit
[F2](RCV) ..... Receive
[F6](PRM) ..... Parameter settings

■About the Data Type Selection Screen

Whenever you press [F1](TRN) to send data or [F2](RCV) to receive data, a data type selection screen appears on the display.

Send Unit

[F1](TRN)

```
TRANSMIT DATA
▶ALL
 Program
 Editor
 Function Memory
 Matrix
 Statistics
 Variable Memory  ↓
```

Pointer — Indicates more below

Receive Unit

[F2](RCV)

```
RECEIVE DATA
▶ALL
 Program
 Editor
 Function Memory
 Matrix
 Statistics
 Variable Memory  ↓
```

The following table describes what each of these items means. You will learn later how to make a selection using these screens.

Selection	Meaning
ALL	All data from Program to Equation
Program	Program data
Editor	File names and file data
Function Memory	Function memory contents
Matrix	Matrix memory contents
Statistics	Single-variable and paired-variable statistical data
Variable Memory	Value memory and extended memory contents
Range	Graph range parameters
Factor	Factor function zoom ratios
Table	Table & Graph function data
Graph Function	Graph functions
Dynamic Graph	Dynamic Graph function data
Equation	Equation coefficients
Back Up	All memory contents, including mode settings

Note

- If the selections you make on the send unit and receive unit do not match, a TRANSMIT ERROR will be generated on the sender and a RECEIVE ERROR will be generated on the receiver.

13-5 Setting Communications Parameters

Before you can perform data communications, you must first set up certain hardware parameters to make sure that the two units are able to understand each other. The parameters of the sender and the receiver must be identical for them to be able to communicate correctly. There are two hardware parameters that you can set.

Parameter	Settings
PARITY	EVEN ODD NONE
Speed (BPS)	1200 2400 4800 9600

■To Set fx-9700GH Parameters

Starting from the LINK Mode:

[F6](PRM)

Pointer

```
PARAMETERS
▶PARITY
 EVEN ODD NONE
 BPS
 1200 2400 4800 9600
TO SELECT:[↓][↑]
          [←][→]
TO SET    :[EXE]
```

*The parameters that are currently set are highlighted on the display.

The pointer indicate which parameter you can change. Use ◀ and ▶ to move the highlighting and change the parameter where the pointer is located.

▶▶

```
PARAMETERS
▶PARITY
 EVEN ODD NONE
 BPS
 1200 2400 4800 9600
TO SELECT:[↓][↑]
          [←][→]
TO SET    :[EXE]
```


Use ▲ and ▼ to move the pointer up and down.
After the parameters are highlighted the way you want, press [EXE] to store them.

[EXE]

```
COMMUNICATION

 PARITY:NONE
 BPS    :9600
```

- To abort the parameter setting procedure and return the settings to what they were before you cnanged them, press [AC] before pressing [EXE] to strore the parameters.

13-6 Using ALL, Range, and Factor

The following procedures show how to send data using ALL, Range, and Factor from one fx-9700GH unit to another. The example procedure shows an operation using ALL only, but the procedures for Range and Factor are identical.

● To send data using ALL

Send Unit

Starting from the LINK Mode, press the function key to enter the send mode.

[F1](TRN)

```
TRANSMIT DATA
▶ALL
 Program
 Editor
 Function Memory
 Matrix
 Statistics
 Variable Memory  ↓
```

Make sure that the pointer is located at ALL, and press [EXE] to specify it as the data type.

Receive Unit

Starting from the LINK Mode, press the function key to enter the receive mode.

[F2](RCV)

```
RECEIVE DATA
▶ALL
 Program
 Editor
 Function Memory
 Matrix
 Statistics
 Variable Memory  ↓
```

Make sure that the pointer is located at ALL, and press [EXE] to specify it as the data type.

[EXE]

```
==TRANSMIT==
ALL

[YES]          [NO]
 F1             F6
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL DATA

TO STOP  :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE
ALL DATA

   PRESS [AC]
```

[EXE]

```
==RECEIVE==
ALL

[YES]          [NO]
 F1             F6
```

Press [F1](YES) start the receive operation, or [F6](NO) to abort without receiving anything.

[F1](YES)

```
==RECEIVING==

ALL DATA

TO STOP  :[AC]
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE
ALL DATA

   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

Warning!

Transferring data using ALL causes data in the applicable memory areas of the receiving unit to be replaced by the received data. Make sure that you do not need the data stored in the receiving unit before you start an operation using ALL.

13-7 Using Program, Function Memory, Matrix, and Graph Function

The following procedures show how to send data using Program, Function Memory, Matrix, and Graph Function from one fx-9700GH unit to another. In each case, you can send all of the Program, Function Memory, Matrix, or Graph Function data, or a specific data item. The example procedure shows an operation using Program only, but the procedures for Function Memory, Matrix, and Graph Function are identical.

• To send all data using Program

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Program, and press [EXE] to specify it as the data type.

[▼][EXE]

```
==TRANSMIT==
PROGRAM

ALL ONE
 F1  F2
```

Press [F1](ALL) to specify all programs.

[F1](ALL)

```
==TRANSMIT==

ALL PROGRAM FILES

[YES]          [NO]
 F1             F6
```

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Program, and press [EXE] to specify it as the data type.

[▼][EXE]

```
==RECEIVE==
PROGRAM

[ALL] ONE
 F1  F2
```

Press [F1](ALL) to specify all programs.

[F1](ALL)

```
==RECEIVING==

ALL PROGRAM FILES

TO STOP  :[AC]
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL PROGRAM FILES


TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE
ALL PROGRAM FILES


   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE
ALL PROGRAM FILES


   PRESS [AC]
```

• To send a specific data item using Program

Send Unit

[F1](TRN)

[▼][EXE]

Press [F2](ONE) to specify one program.

[F2](ONE)

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
     23680 Bytes Free
▶Prog 0:empty
 Prog 1:'MATHEMATICS
 Prog 2:empty
 Prog 3:empty
```

Receive Unit

[F2](RCV)

[▼][EXE]

Press [F2](ONE) to specify one program.

[F2](ONE)

```
==RECEIVE==
TO SELECT:[↓][↑]
TO START :[EXE]
     12345 Bytes Free
▶Prog 0:empty
 Prog 1:empty
 Prog 2:empty
 Prog 3:empty
```


•In the case of Function Memory, Matrix, and Graph Function, the remaining number of bytes in the fourth line is not displayed.

Use the [▲] and [▼] keys to move the pointer to the left of the program area you want to send. After you select the program area press [EXE] to start the send operation.

[▼][EXE]

```
==TRANSMITTING==

TO STOP   :[AC]
     23680 Bytes Free
 Prog 0:empty
▶Prog 1:'MATHEMATICS
 Prog 2:empty
 Prog 3:empty
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

After the send operation is complete, the program selection display appears, so you can send another program if you want.

•In the case of Function Memory, Matrix, and Graph Function, the remaining number of bytes in the fourth line is not displayed.

Use the [▲] and [▼] keys to move the pointer to the left of the program area where you want the received program to be stored. After you select the program area press [EXE] to start the receive operation.

[▼][EXE]

```
==RECEIVING==

TO STOP   :[AC]
     12345 Bytes Free
 Prog 0:empty
▶Prog 1:empty
 Prog 2:empty
 Prog 3:empty
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

After the receive operation is complete, the program area selection display appears, so you can receive another program if you want.

13-8 Using Editor

The following procedure shows how to send files using the Editor from one fx-9700GH unit to another. You can send all of the Editor files or a specific file.

• To send all files using Editor

Send Unit

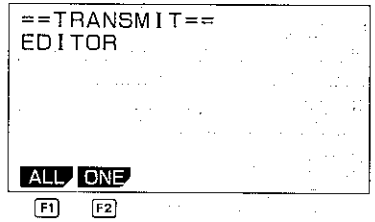
Starting from the LINK Mode, press the [F1](TRN) to enter the send mode.

Receive Unit

Starting from the LINK Mode, press the [F2](RCV) to enter the receive mode.

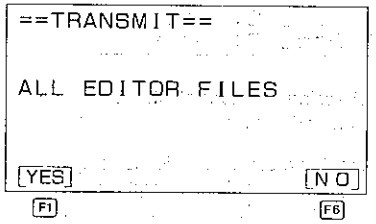
Move the pointer to Editor, and press [EXE] to specify it as the data type.

[▼][▼][EXE]



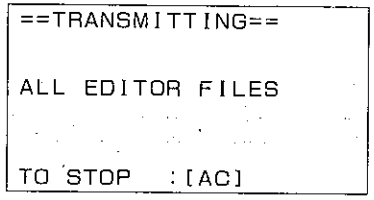
Press [F1](ALL) to specify all files.

[F1](ALL)



Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

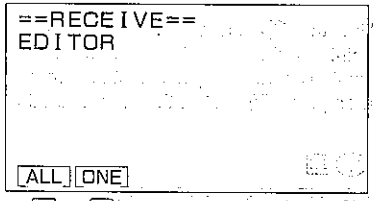
[F1](YES)



*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

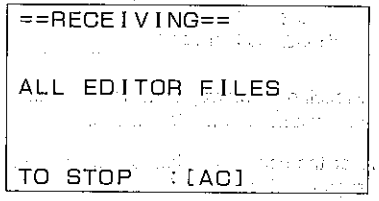
Move the pointer to Editor, and press [EXE] to specify it as the data type.

[▼][▼][EXE]



Press [F1](ALL) to specify all files.

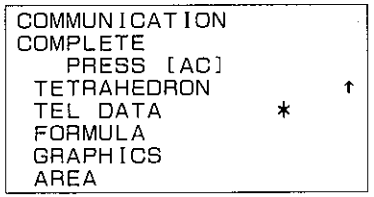
[F1](ALL)



The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

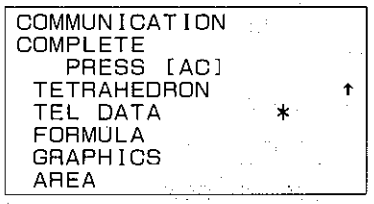
*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the send operation is complete.



*Press [AC] to return to the LINK Mode.

The following appears after the receive operation is complete.



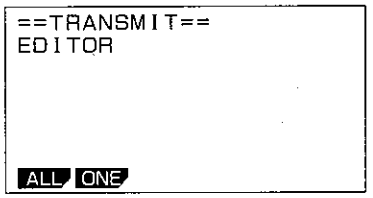
• To send a specific file using Editor

Send Unit

Starting from the LINK Mode, press the [F1](TRN) to enter the send mode.

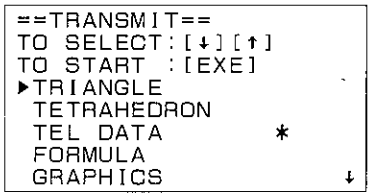
Move the pointer to Editor, and press [EXE] to specify it as the data type.

[▼][▼][EXE]



Press [F2](ONE) to specify one file.

[F2](ONE)



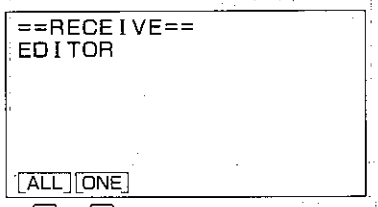
*The message "No File in Memory" appears if there are no files in memory.

Receive Unit

Starting from the LINK Mode, press the [F2](RCV) to enter the receive mode.

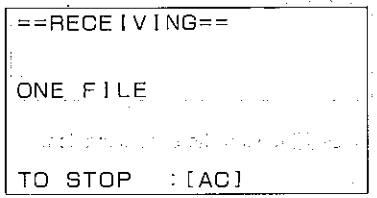
Move the pointer to Editor, and press [EXE] to specify it as the data type.

[▼][▼][EXE]



Press [F2](ONE) to specify one file.

[F2](ONE)



Use the ▲ and ▼ keys to move the pointer to the left of the file you want to send. After you select the file press EXE to start the send operation.

▼EXE

```
==TRANSMITTING==

TO STOP   :[AC]
 TRIANGLE
▶TETRAHEDRON
 TEL DATA        *
 FORMULA
 GRAPHICS        ↓
```

*Pressing AC interrupts the send operation and returns to the LINK Mode.

*If the file you select requires a password, a display appears asking you to input it.

▼▼EXE

```
Filename
[TEL DATA     ]
Password?
[A            ]


                SYM
```

Input the correct password.

C A S I O

```
Filename
[TEL DATA     ]
Password?
[CASIOA       ]


                SYM
```

Press EXE to start the send operation.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing AC interrupts the receive operation and returns to the LINK Mode.

After the send operation is complete, the file selection display appears, so you can send another file if you want.

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
 TRIANGLE
▶TETRAHEDRON
 TEL DATA        *
 FORMULA
 GRAPHICS        ↓
```

After the receive operation is complete, the file selection display appears, so you can receive another file if you want.

```
COMMUNICATION
COMPLETE
    PRESS [AC]
 NAME LIST
 MATHEMATICS
 TETRAHEDRON
```

13-9 Using Statistics, Variable Memory, Table, and Equation

The following procedures show how to send data using Statistics, Variable Memory, Table, and Equation from one fx-9700GH unit to another. The example procedure shows an operation using Statistics only, but the procedures for Variable Memory, Table, and Equation are identical unless otherwise noted.

• To send Statistics data

Send Unit

Starting from the LINK Mode, press F1(TRN) to enter the send mode.

Move the pointer to Statistics, and press EXE to specify it as the data type.

▼▼▼▼▼EXE

```
==TRANSMIT==
STATISTICS




 SD  REG
```

F1 F2

Receive Unit

Starting from the LINK Mode, press F2(RCV) to enter the receive mode.

Move the pointer to Statistics, and press EXE to specify it as the data type.

▼▼▼▼▼EXE

```
==RECEIVE==
STATISTICS




 SD  REG
```

F1 F2

Press a function key to specify the data type.

•Statistics

F1(SD)

Single-variable data

F2(REG)

Paired variable data

•Variable Memory

F1(ALL)

Value memories A-Z, r, θ, extended memories

F2(A ~ Z)

Value memories A-Z, r, θ

F3(Dfm)

Extended memories

•Table

F1(FUNC)

Table & Graph expressions, table ranges, table contents

F2(RECR)

Table & Graph recursion formulas, table ranges, table contents

•Equation

F1(SIML)

Coefficients for simultaneous equations with two to six unknowns

F2(POLY)

Coefficients for quadratic and cubic equations

Press a function key to specify the data type.

•Statistics

F1(SD)

Single-variable data

F2(REG)

Paired variable data

•Variable Memory

F1(ALL)

Value memories A-Z, r, θ, extended memories

F2(A ~ Z)

Value memories A-Z, r, θ

F3(Dfm)

Extended memories

•Table

F1(FUNC)

Table & Graph expressions, table ranges, table contents

F2(RECR)

Table & Graph recursion formulas, table ranges, table contents

•Equation

F1(SIML)

Coefficients for simultaneous equations with two to six unknowns

F2(POLY)

Coefficients for quadratic and cubic equations

• To send single-variable (standard deviation) data

Press F1(SD) to specify single-variable (standard deviation) data.

F1(SD)

```
==TRANSMIT==

SD DATA


[YES]          [NO]
 F1             F6
```

Press F1(YES) to start the send operation, or F6(NO) to abort without sending anything.

F1(YES)

```
==TRANSMITTING==

SD DATA


TO STOP   :[AC]
```

*Pressing AC interrupts the send operation and returns to the LINK Mode.

Press F1(SD) to specify single-variable (standard deviation) data.

F1(SD)

```
==RECEIVING==

SD DATA


TO STOP   :[AC]
```

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing AC interrupts the receive operation and returns to the LINK Mode.

• To send paired-variable (regression)

Send Unit

Press F2(REG) to specify paired-variable (regression) data.

F2(REG)

```
==TRANSMIT==

REG DATA


[YES]          [NO]
 F1             F6
```

Receive Unit

Press F2(REG) to specify paired-variable (regression) data.

F2(REG)

```
==RECEIVING==

REG DATA


TO STOP   :[AC]
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

REG DATA


TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE
REG DATA


   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE
REG DATA


   PRESS [AC]
```


13-10 Using Dynamic Graph

The following procedures show how to send data using Dynamic Graph from one fx-9700GH unit to another. You can send all of the Dynamic Graph data, or a specific data item.

• To send all data using Dynamic Graph

Send Unit

Starting from the LINK Mode, press the [F1](TRN) to enter the send mode.

Move the pointer to DYNAMIC GRAPH, and press [EXE] to specify it as the data type.

[▼][▼][▼][▼][▼][▼][▼][▼][▼][▼]
[▼][EXE]

```
==TRANSMIT==
DYNAMIC FUNCTION


 ALL  ONE
```

[F1] [F2]

Press [F1](ALL) to specify all data.

[F1](ALL)

```
==TRANSMIT==

ALL DYNAMIC FUNCTIONS


[YES]          [NO]
```

[F1] [F6]

Receive Unit

Starting from the LINK Mode, press the [F2](RCV) to enter the receive mode.

Move the pointer to DYNAMIC GRAPH, and press [EXE] to specify it as the data type.

[▼][▼][▼][▼][▼][▼][▼][▼][▼][▼]
[▼][EXE]

```
==RECEIVE==
DYNAMIC FUNCTION


[ALL] [ONE]
```

[F1] [F2]

Press [F1](ALL) to specify all data.

[F1](ALL)

```
==RECEIVING==

ALL DYNAMIC FUNCTIONS


TO STOP   :[AC]
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

ALL DYNAMIC FUNCTIONS


TO STOP   :[AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE
ALL DYNAMIC FUNCTIONS


   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE
ALL DYNAMIC FUNCTIONS


   PRESS [AC]
```

• To send a specific data item using Dynamic Graph

Send Unit

After entering the send mode and selecting Dynamic Graph, press [F2](ONE) to specify one data item.

[F2](ONE)

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
▶Y=AX+2
 Y=A√X
 Y=sin AX+cos BX
 Y=√(X+A)
 Y=AX²-5                ↓
```

Receive Unit

After entering the receive mode and selecting Dynamic Graph, press [F2](ONE) to specify one data item.

[F2](ONE)

```
==RECEIVING==

ONE DYNAMIC FUNCTION


TO STOP   :[AC]
```


Use the [▲] and [▼] keys to move the pointer to the left of the Dynamic Graph Function you want to send. After you select the program press [EXE] to start the send operation.

[▼][▼][EXE]

```
==TRANSMITTING==

TO STOP   :[AC]
 Y=AX+2
 Y=A√X
▶Y=sin AX+cos BX
 Y=√(X+A)
 Y=AX²-5                ↓
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

After the send operation is complete, the program selection display appears, so you can send another function if you want.

```
==TRANSMIT==
TO SELECT:[↓][↑]
TO START :[EXE]
 Y=AX+2
 Y=A√X
▶Y=sin AX+cos BX
 Y=√(X+A)
 Y=AX²-5                ↓
```

*Press [AC] to return to the LINK Mode.

The receiving unit goes directly into receive standby. The actual receive operation starts as soon as the sending unit starts to send data.

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

After the receive operation is complete, the program area selection display appears, so you can receive another function if you want.

```
==RECEIVE==
TO SELECT:[↓][↑]
TO START :[EXE]
▶Y=sin AX+cos BX
 Y=AX-5
 Y=2X²+B
 Y=Csin X
```

13-11 Using Back Up to Send All Mode Settings and Memory Data

The following procedures show how to send all mode settings and memory data from one fx-9700GH unit to another. This operation is helpful if you wish to back up memory contents using another unit.

Important

If the cable connecting the units becomes disconnected, if the parameter settings of the two units do not match, or if any other abnormality occurs during the backup operation, the data in the receiving unit may become corrupted. If this happens, you will have to reset the receiving unit, deleting all data in its memory. Make sure that you take precautions to avoid problems during the backup operation before starting actual data transfer.

• To back up all data

Send Unit

Starting from the LINK Mode, press [F1](TRN) to enter the send mode.

Move the pointer to Back Up, and press [EXE] to specify it as the data type.

```
==TRANSMIT==
BACK UP

[YES]          [NO]
 F1             F6
```

Press [F1](YES) to start the send operation, or [F6](NO) to abort without sending anything.

[F1](YES)

```
==TRANSMITTING==

BACK UP

TO STOP  : [AC]
```

*Pressing [AC] interrupts the send operation and returns to the LINK Mode.

The following appears after the send operation is complete.

```
COMMUNICATION
COMPLETE
BACK UP

   PRESS [AC]
```

*Press [AC] to return to the LINK Mode.

Receive Unit

Starting from the LINK Mode, press [F2](RCV) to enter the receive mode.

Move the pointer to Back Up, and press [EXE] to specify it as the data type.

```
==RECEIVE==
BACK UP

[YES]          [NO]
 F1             F6
```

Press [F1](YES) to start the receive operation, or [F6](NO) to abort without receiving anything.

[F1](YES)

```
==RECEIVING==

BACK UP

TO STOP  : [AC]
```

*Pressing [AC] interrupts the receive operation and returns to the LINK Mode.

The following appears after the receive operation is complete.

```
COMMUNICATION
COMPLETE
BACK UP

   PRESS [AC]
```


13-12 Screen Copy Function

The following procedure sends a bit mapped screen shot of the display to a connected computer or Label Printer.

■To Copy the Screen

1. Connect the fx-9700GH to a personal computer (page 297) or to a CASIO Label Printer (page 297).
2. Display the set up screen and specify COPY as the function of the [X-Bus] key (M-DISP/COPY Mode) (page 24).
3. Display the screen you want to copy.
4. Set up the personal computer or Label Printer to receive data. When the other unit is ready to receive, press [X-Bus] to start the send operation.

You cannot send the following types of screens to a computer.

- The screen that appears while a data communication operation is in progress.
- A screen that appears while a calculation is in progress.
- The screen that appears following the reset operation.
- The low battery message.

Notes

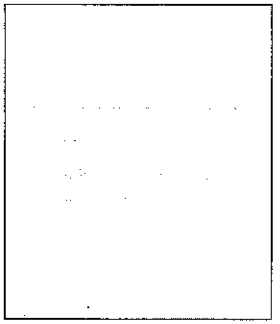
- The flashing cursor is not included in the screen image that is sent from the fx-9700GH.
- If you send a screen shot of any of the screens that appear during the data send operation, you will not be able to then use the sent screen to proceed with the data send operation. You must exit the data send operation that produced the screen you sent and restart the send operation before you can send additional data.
- You cannot use 6mm wide tape to print a screen shot of a graph.

A313043-2

13-13 Data Communications Precautions

Note the following precautions whenever you perform data communications.

- A TRANSMIT ERROR occurs whenever you try to send data to a receiving unit that is not yet standing by to receive data. When this happens, press AC to clear the error and try again, after setting up the receiving unit to receive data.
- A RECEIVE ERROR occurs whenever the receiving unit does not receive any data approximately six minutes after it is set up to receive data. When this happens, press AC to clear the error.
- A TRANSMIT ERROR or RECEIVE ERROR occurs during data communications if the cable becomes disconnected, if the parameters of the two units do not match, or if any other communications problem occurs. When this happens, press AC to clear the error and correct the problem before trying data communications again. In this case, any data received before the problem occurred is cleared from the receiving unit's memory.
- A MEMORY FULL operation occurs if the receiving unit memory becomes full during data communications. When this happens, press AC to clear the error and delete unneeded data from the receiving unit to make room for the new data, and then try again.



Appendix

The appendix contains information on battery replacement, error messages, specifications, and other details.

Appendix A Power Supply

This unit is powered by four AAA-size (LR03 (AM4) or UM-4) batteries. In addition, it uses a single CR2032 lithium battery as a back up power supply for the memory.

■When to Replace Batteries

Replace batteries when the display of the calculator becomes dim and difficult to read, even if you adjust the contrast (page 27) to make it darker.
If the following message appears on the display, immediately stop using the calculator and replace batteries. If you try to continue using the calculator, it will automatically switch power off, in order to protect memory contents. You will not be able to switch power back on until you replace batteries.

```
*** Low battery ***
```

Be sure to replace batteries at least once every two years, no matter how much you use the calculator during that time.

Warning!

If you remove both the main power supply and the memory back up batteries at the same time, all memory contents will be erased. Be sure to read the following section before doing anything.

■Replacing Batteries

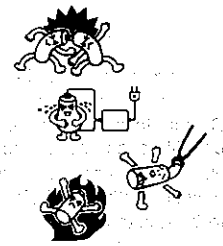
- Be sure that you have back up copies of all your memory contents before replacing batteries.
- Never remove the main power supply and the memory back up batteries at the same time. Doing so will erase the contents of the memory.
- Be sure that the calculator is switched off whenever you replace batteries. If the calculator is on, data stored in memory will be erased.
- Never switch the calculator on while batteries are not loaded or while the battery holder is not in place. Doing so will erase the contents of the memory.

Precautions:
Incorrectly using batteries can cause them to burst or leak, possibly damaging the interior of the unit. Note the following precautions:

- Be sure that the positive ⊕ and negative ⊖ poles of each battery are facing in the proper directions.
- Never mix batteries of different types.
- Never mix old batteries and new ones.

- Never leave dead batteries in the battery compartment.
- Remove the batteries if you do not plan to use the unit for long periods.
- Never try to recharge the batteries supplied with the unit.
- Do not expose batteries to direct heat, let them become shorted, or try to take them apart.

(Should a battery leak, clean out the battery compartment of the unit immediately, taking care to avoid letting the battery fluid come into direct contact with your skin.)

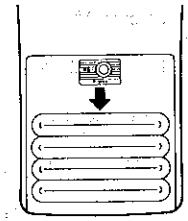


Keep batteries out of the reach of small children. If swallowed, consult with a physician immediately.

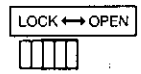
• To replace the main power supply batteries

① Switch the power of the calculator off.

② Slide the battery compartment cover on the back of the unit in the direction indicated by the arrow.

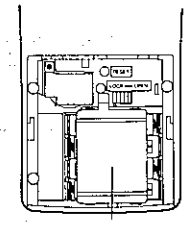


③ Slide the switch to the OPEN position, and then remove the battery holder.



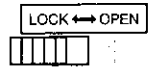
④ Remove the four old batteries.

⑤ Load a new set of four batteries, making sure that their positive ⊕ and negative ⊖ ends are facing in the proper directions.



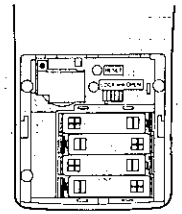
Battery holder

⑥ Re-install the battery holder and you press down on the batteries with it. Next, slide the battery switch to the LOCK position.



⑦ Replace the battery compartment cover, sliding it in the direction opposite that indicated by the arrow.

- Power supplied by memory back-up batteries while the main power supply batteries are removed retains memory contents.

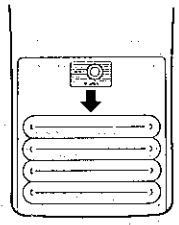


A313043-2

Important

*Never remove the main power supply and the memory back up batteries from the unit at the same time.
*Be sure to switch the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.
*Never switch power on while main power supply batteries are removed from the unit or while the battery holder is not securely in place. Doing so will cause data in memory to be deleted.
*Make sure that you do not press [F1](YES) when the reset confirmation message is shown on the display. Doing so will reset the calculator and clear all data from its memory.
*Be sure to replace all four batteries with new ones.

• To replace the memory back up battery



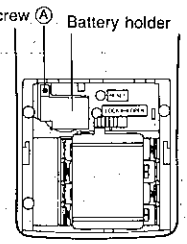
①Switch the power of the calculator off.

②Slide the battery compartment cover on the back of the unit in the direction indicated by the arrow.

③Remove screw Ⓐ from the battery holder.

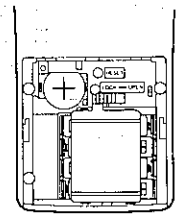
④Remove the old battery.

⑤Wipe 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.



⑥Replace the battery holder and fasten it in place with screw Ⓐ.

⑦Replace the battery compartment cover, sliding in the direction opposite that indicated by the arrow.



⑧Switch the power of the calculator on and check for proper operation.

Important

*Before replacing the memory backup battery, switch on the unit and check to see if the "Low battery" message appears on the display. If it does, replace the main power supply batteries before replacing the back up power supply battery.
*Never remove the main power supply and the memory back up batteries from the unit at the same time.

*Be sure to switch the unit off before replacing batteries. Replacing batteries with power on will cause data in memory to be deleted.
*Be sure to replace the back up power supply battery at least once 15 months, regardless of how much you use the unit during that time. Failure to do so will cause data in memory to be deleted.

■About the Auto Power Off Function

The calculator switches power off automatically if you do not perform any key operation for about 6 minutes. To restore power, press [AC/ON].

Appendix B To Reset the Calculator

Warning!

The procedure described here clears all memory contents. Never perform this operation unless you want to totally clear the memory of the calculator.

Strong electrostatic charge can corrupt the operating system of the calculator, which interferes with correct operation. When this happens (or if you want to totally clear the memory for any other reason), you have to reset the calculator.

• To reset the calculator

①Switch the power of the calculator on.
②Press [MENU] to display the Main Menu.
③Use the cursor keys to select the **RESET** icon and then press [EXE].

```
**********************
*        RESET       *
**********************

RESET ALL MEMORIES?

[YES]   RESET ALL   [NO]
 [F1]                [F6]
```

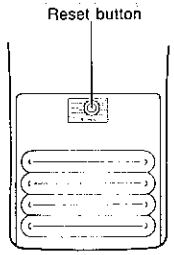
④Press [F1](YES) to reset the calculator, or [F6](NO) to abort the reset operation.

[F1](YES)

```
**********************
*                    *
* RESET              *
*                    *
*   ALL MEMORIES!    *
*                    *
*                    *
**********************
```

Resetting the calculator initializes the unit to the following settings.

Item	Initial Setting
Mode	COMP
Unit of Angular Measurement	Deg
Norm	Norm 1
BASE-N	Dec
Value Memories	Clear
Expanded Memory	Clear
Function Memory	Clear
Ans Memory	Clear
Graphic Display	Clear
Text Display	Clear
Equation Memory	Clear
Statistical Data Memory	Clear
Matrix Memory	Clear
Graphic Function Memory	Clear
Dynamic Graph Functions	Clear
Table & Graph Data	Clear
Input Buffer	Clear
Program/File Memory	Clear



- A RESET button is located on the back of the unit. Switching power on and then pressing this button with a thin, pointed object displays the reset confirmation message shown on page 323.
- Pressing the RESET button while power is off will switch power on, but the reset confirmation message will not appear.
- Be sure to always keep written copies of all imortant data in case you accidently delete it using the RESET operation.

Appendix C Function Reference

■Manual Calculations

Mode specification	COMP Mode (see page 20)	Arithmetic and function calculations
	BASE Mode (see page 20)	Binary, octal, decimal, hexadecimal conversions and calculations, logical operations
	SD Mode (see page 20)	Standard deviation calculations (1-variable statistical)
	REG Mode (see page 20)	Regression calculations (paired variable statistical)
	MAT Mode (see page 20)	Matrix calculations
	TABLE Mode (see page 21)	Function and recursion calculations, and numeric table generation
	EQUA Mode (see page 21)	Linear equations with two to six unknowns, quadratic equations, and cubic equations
Statistical graph	SD Mode (see page 90, 163)	For production of single variable statistical graphs (bar graphs, line graphs, normal distribution curves)
	REG Mode (see page 97, 167)	For production of paired variable statistical graphs (regression lines)
Functions	Type A functions	Function command input immediately after numeric value [x^2, x^{-1}, $x!$, ° ' ", ENG symbols]
	Type B functions	Function command input immediately before numeric value [sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, log, ln, e^x, 10^x, $\sqrt{}$, $\sqrt[3]{}$, etc.]
	Paired variable functions	Function command input between two numeric values, numeric value enclosed in parentheses input immediately after function command [A ^ B (A to the Bth power), B $\sqrt[x]{}$ A (A to the 1/Bth power), Pol (A, B), Rec (A, B)] **A and B are numeric values.*

Functions	Immediately executed functions	Displayed value changed with each press of a key [ENG, $\overleftarrow{\text{ENG}}$, °′″, $\overleftarrow{\text{°′″}}$]
Binary, octal, decimal, hexadecimal calculations (see page 49, 50)	Setting number system	Decimal ..... F1(Dec)EXE Hexadecimal ..... F2(Hex)EXE Binary ..... F3(Bin)EXE Octal ..... F4(Oct)EXE
	Number system specification	Number system for the numeric value entered immediately after can be specified regardless of the currently set number system. To specify: Decimal ..... F5(d~o)F1(d) Hexadecimal ..... F5(d~o)F2(h) Binary ..... F5(d~o)F3(b) Octal ..... F5(d~o)F4(o)
	Logical operations	Input numeric values are converted to binary and each bit is tested. Result is converted back to number system used for input, and then displayed. Not ..... Reverse of each bit and ..... Logical product of each bit or ..... Logical sum of each bit xor ..... Exclusive logical sum of each bit xnor ..... Exclusive negative logical sum of each bit
Standard deviation calculations (see page 90)	Data clear	SHIFT CLR F2(Scl)EXE
	Data input	Data [;frequency] F1(DT) **Frequency can be omitted.*
	Data deletion	Data [;frequency] F2(CL) **Frequency can be omitted.*
	Result display	Number of data (n) ..... F5(Σ)F3(n)EXE Sum (Σx) ..... F5(Σ)F2(Σx)EXE Sum of squares (Σx^2) .... F5(Σ)F1(Σx^2)EXE Mean ($\bar{x}$) ..... F4(DEV)F1($\bar{x}$)EXE Population standard deviation ($x\sigma_n$) ..... F4(DEV)F2($x\sigma_n$)EXE Sample standard deviation ($x\sigma_{n-1}$) ..... F4(DEV)F3($x\sigma_{n-1}$)EXE
	Probability distribution calculations	P(t) ..... F6(PQR)F1(P() Q(t) ..... F6(PQR)F2(Q() R(t) ..... F6(PQR)F3(R() t(x) ..... F6(PQR)F4(t()

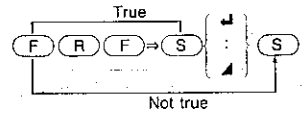
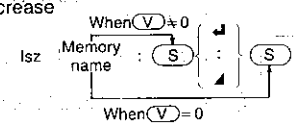
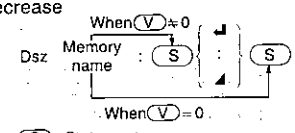
Standard deviation calculations (see page 90)	Data storage	F4(DEV)F4(▽)F1(Mod) F4(DEV)F4(▽)F2(Med) F4(DEV)F4(▽)F3(Max) F4(DEV)F4(▽)F4(Min)
Regression calculations (see page 97)	Data clear	SHIFT CLR F2(Scl)EXE
	Data input	x data, y data [;frequency] F1(DT) **Frequency can be omitted.*
	Data deletion	x data, y data [;frequency] F2(CL) **Frequency can be omitted.*
	Result display	Number of data (n) ..... F5(Σ)F3(n)EXE Sum of x (Σx) ..... F5(Σ)F2(Σx)EXE Sum of y (Σy) ..... F5(Σ)F5(Σy)EXE Sum of squares of x (Σx^2) ..... F5(Σ)F1(Σx^2)EXE Sum of squares of y (Σy^2) ..... F5(Σ)F4(Σy^2)EXE Sum of products of x and y (Σxy) ..... F5(Σ)F6(Σxy)EXE Mean of x ($\bar{x}$) ..... F4(DEV)F1($\bar{x}$)EXE Mean of y ($\bar{y}$) ..... F4(DEV)F4($\bar{y}$)EXE Population standard deviation of x ($x\sigma_n$) ..... F4(DEV)F2($x\sigma_n$)EXE Population standard deviation of y ($y\sigma_n$) ..... F4(DEV)F5($y\sigma_n$)EXE Sample standard deviation of x ($x\sigma_{n-1}$) ..... F4(DEV)F3($x\sigma_{n-1}$)EXE Sample standard deviation of y ($y\sigma_{n-1}$) ..... F4(DEV)F6($y\sigma_{n-1}$)EXE Constant term of regression formula (A) ..... F6(REG)F1(A)EXE Regression coefficient (B) ..... F6(REG)F2(B)EXE Correlation coefficient (r) ..... F6(REG)F3(r)EXE Estimated value of x ($\hat{x}$) ..... F6(REG)y data F4($\hat{x}$)EXE Estimated value of y ($\hat{y}$) ..... F6(REG)x data F5($\hat{y}$)EXE

Special functions	Ans	The latest result obtained in manual or program calculations is stored in memory. It is recalled by pressing [SHIFT][Ans]. *Mantissa of numeric value is 15 digits.*
	Replay	•After calculation results are obtained, the formula can be recalled by pressing either ◀ or ▶. •If an error is generated, pressing either ◀ or ▶ will cancel the error and the point where the error was generated will be indicated by a blinking cursor.
	Multistatement	Colons are used to join a series of statements or calculation formulas. If joined using "◢", the calculation result to that point is displayed.
	Memory	The number of memories can be expanded from the standard 28. Memories can be expanded in units of one up to 2400 (for a total of 2428). Eight bytes are required for one memory. [SHIFT][Defm] number of memories [EXE].
Graph function	Range	Graph range settings Xmin ..... Minimum value of x Xmax ..... Maximum value of x Xscale ..... Scale of X-axis (space between points) Ymin ..... Minimum value of y Ymax ..... Maximum value of y Yscale ..... Scale of Y-axis (space between points) T, θ min .... Minimum value of T/θ T, θ max ... Maximum value of T/θ T, θ pitch .. Pitch of T/θ
	Trace	Moves pointer on graph. Current coordinate location is displayed.
	Plot	Marks pointer (blinking dot) at any coordinate on the graph display.
	Line	Connects with a straight line two points created with plot function.
	Box zoom	Defines area for zoom in.
	Factor zoom	Defines factor for zoom in/zoom out.
	Auto range	Automatically sets the y-axis range for drawing of a graph that uses the entire range of the y-axis.

Graph function	Graph adjust	Adjusts the ratio of the x-axis and y-axis ranges to 1:1.
	Pointer coordinate rounding	Cuts off decimal part of the coordinate value at the current pointer location and rounds the value to the appropriate number of significant digits.
	Original	Returns a graph to its original dimensions after a zoom, auto range, or graph adjust operation.
	Scroll	Scrolls screen to view parts of graphs that are off the display.
	Graph solve	Provides solutions of functions •Root ..... [F1](ROOT) •Maximum Value ..... [F2](MAX) •Minimum Value ..... [F3](MIN) •y-Axis Intercept ..... [F4](Y-ICPT) •Graph Intersect..... [F5](ISCT) •y-Coordinate at Any Point... [F6](▽)[F1](Y-CAL) •x-Coordinate at Any Point... [F6](▽)[F2](X-CAL) •Derivative ..... [F6](▽)[F3](d/dx)
Dual graph function	Range	Sets independent range for active graph and inactive graph.
	Copy	Draws a graph on the inactive screen using the same function for the graph on the active screen.
	Change	Switches the active screen graph with the inactive screen graph.
Dynamic graph function	DYNA Mode (see page 232)	Changes coefficients within a specified range and continually draws graphs in accordance with the changes.
Table & Graph function	TABLE Mode (see page 242)	Draws graphs for functions and recursion formulas in accordance with a generated numeric table.

■Program Calculations

Program input	Calculation mode	Mode that conforms with program specified by: SHIFT SETUP F1(COMP) (F2(BASE), F3(SD), F4(REG), F5(MAT))
	Program area specification	Cursor is moved to the desired program area name (Prog 0 through Prog 9, Prog A through Prog Z, Prog r, Prog θ) using ▲ and ▼, and EXE is pressed.
	File editor specification	The operation F1(NEW) <file name> EXE displays the data menu.
Program execution	Program area specification	Execution starts with SHIFT PRGM F3(Prog) program area name EXE. Program area name: Prog 0 through Prog 9, Prog A through Prog Z, Prog r, Prog θ
	File editor specification	Cursor is moved to the desired file name stored in program data using ▲ and ▼, and F3(RUN) is pressed.
Program editing	Program area specification	Cursor is moved to the desired program area name (Prog 0 through Prog 9, Prog A through Prog Z, Prog r, Prog θ) using ▲ or ▼, and EXE is pressed.
	File editor specification	Cursor is moved to the desired file name stored in program data using ▲ and ▼, and EXE is pressed.
	Editing	Cursor is moved to position to be edited using ◀, ▶, ▲ or ▼. •Press correct key for corrections. •Press DEL for deletions. •Press SHIFT INS to specify insert mode for insertion.
Program delete	Deletes specific program	Cursor is moved to the desired program area name (Prog 0 through Prog 9, Prog A through Prog Z, Prog r, Prog θ) using ▲ and ▼, and F2(DEL)F1(YES) is pressed.
	Clears all programs	Press F3(DEL·A)F1(YES)
	Delete specific file name stored in program data	Cursor is moved to the desired file name stored in program data using ▲ and ▼, and F5(DEL)F1(YES) is pressed.

Program commands	Unconditional jump	Program execution jumps to the Lbl n which corresponds to Goto n. *$n = 0$ through 9
	Conditional jumps	If conditional expression is true, the statement after "⇒" is executed. If not true, execution jumps to the statement following next "↵", ":" or "◢".  (F): Formula (R): Relational operator (S): Statement *The relational operator is: =, ≠, >, <, ≥, ≤.
	Count jumps	The value in a memory is increased or decreased. If the value does not equal 0, the next statement is executed. If it is 0, a jump is performed to the statement following the next "↵", ":" or "◢". Increase  Decrease  (S): Statement (V): Value in memory
	Subroutines	Program execution jumps from main routine to subroutine indicated by Prog n ($n = 0$ through 9, A through Z, r, θ or file name). After execution of the subroutine, execution returns to the point following Prog n in the original program area.

Appendix D Error Message Table

Message	Meaning	Countermeasure
Syn ERROR	①Calculation formula contains an error. ②Formula in a program contains an error.	①Use ◀ or ▶ to display the point where the error was generated and correct it. ②Use ◀ or ▶ to display the point where the error was generated and then correct the program.
Ma ERROR	①Calculation result exceeds calculation range. ②Calculation is performed outside the input range of a function. ③Illogical operation (division by zero, etc.) ④Poor precision in Σ calculation results. ⑤Poor precision in differential calculation results. ⑥Poor precision in integration calculation results. ⑦Cannot find results of equation calculations.	①②③④ Check the input numeric value and correct it. When using memories, check that the numeric values stored in memories are correct. ⑤Try using a smaller value for Δx (x increment/decrement). ⑥Try using a larger value for n (number of partitions). ⑦Check the coefficients of the equation.
Go ERROR	①No corresponding Lbl n for Goto n. ②No program stored in program area Prog n.	①Correctly input a Lbl n to correspond to the Goto n, or delete the Goto n if not required. ②Store a program in program area Prog n, or delete the Prog n if not required.
Ne ERROR	•Nesting of subroutines by Prog n exceeds 10 levels.	•Ensure that Prog n is not used to return from subroutines to main routine. If used, delete any unnecessary Prog n. •Trace the subroutine jump destinations and ensure that no jumps are made back to the original program area. Ensure that returns are made correctly.
Stk ERROR	•Execution of calculations that exceed the capacity of the stack for numeric values or stack for calculations.	•Simplify the formulas to keep stacks within 10 levels for the numeric values and 26 levels for the calculations. •Divide the formula into two or more parts.
Mem ERROR	①Specified expanded value memory does not exist. ②Not enough memory to expand value memories specified number. ③Not enough memory to input a function into function memory. ④Not enough memory to create a matrix using the specified dimension. ⑤Not enough memory to hold matrix calculation result. ⑥Not enough memory to store statistical data. ⑦Not enough memory to input coefficient for equation. ⑧Not enough memory to hold equation calculation result. ⑨Not enough memory to hold function input in the Graph Mode for graph drawing. ⑩Not enough memory to hold function input in the DYNA Mode for graph drawing. ⑪Not enough memory to hold function or recursion input in the TABLE Mode.	①Use [SHIFT] [Delm] to correctly expand the number of value memories. ②③④⑤⑥⑦⑧⑨⑩⑪ •Keep the number of value memories you use for the operation within the number of value memories currently available. •Simplify the data you are trying to store to keep it within the available memory capacity. •Delete no longer needed data to make room for the new data.
Arg ERROR	Incorrect argument specification for a command that requires an argument.	Correct the argument. •Scl n, Fix n: n = integer from 0 through 9. •Lbl n, Goto n: n = integer from 0 through 9. •Prog n: n = 0 through 9, A through Z, r, θ. •Defm n: n = integer from 0 up to the number of remaining bytes.
Dim ERROR	•Illegal dimension used during matrix calculations.	•Check matrix dimension.

TRANSMIT ERROR!	Problem with cable connection or parameter setting during data communications.	•Check cable connection. •Check to see that the parameters of the sending unit and receiving unit are identical.
RECEIVE ERROR!	Problem with cable connection or parameter setting during data communications.	•Check cable connection. •Check to see that the parameters of the sending unit and receiving unit are identical.
MEMORY FULL!	Memory of receiving unit became full during program data communications.	•Delete some data stored in the receiving unit and try again.

Appendix E Input Ranges

Function	Input range	Internal digits	Accuracy	Notes
$\sin x$ $\cos x$ $\tan x$	(DEG) $\lvert x\rvert < 9\times10^{9}$° (RAD) $\lvert x\rvert < 5\times10^{7}\pi$rad (GRA) $\lvert x\rvert < 1\times10^{10}$grad	15 digits	As a rule, accuracy is ±1 at the 12th digit.	However, for $\tan x$: $\lvert x\rvert \neq 90(2n+1)$:DEG $\lvert x\rvert \neq \pi/2(2n+1)$:RAD $\lvert x\rvert \neq 100(2n+1)$:GRA
$\sin^{-1}x$ $\cos^{-1}x$	$\lvert x\rvert \leqq 1$	〃	〃	
$\tan^{-1}x$	$\lvert x\rvert < 1\times10^{100}$			
$\sinh x$ $\cosh x$	$\lvert x\rvert \leqq 230.258509299$	〃	〃	Note: For sinh and tanh, when $x=0$, errors are cumulative and accuracy is affected at a certain point.
$\tanh x$	$\lvert x\rvert < 1\times10^{100}$			
$\sinh^{-1}x$	$\lvert x\rvert < 5\times10^{99}$	〃	〃	
$\cosh^{-1}x$	$1 \leqq x < 5\times10^{99}$			
$\tanh^{-1}x$	$\lvert x\rvert < 1$			
$\log x$ $\ln x$	$1\times10^{-99} \leqq x < 1\times10^{100}$	〃	〃	
10^{x}	$-1\times10^{100} < x < 100$	〃	〃	
e^{x}	$-1\times10^{100} < x \leqq 230.258509299$			
$\sqrt{x}$	$0 \leqq x < 1\times10^{100}$	〃	〃	
x^{2}	$\lvert x\rvert < 1\times10^{50}$			
$1/x$	$\lvert x\rvert < 1\times10^{100}$, $x \neq 0$	〃	〃	
$\sqrt[3]{x}$	$\lvert x\rvert < 1\times10^{100}$			
$x!$	$0 \leqq x \leqq 69$ (x is an integer)	〃	〃	
nPr nCr	Result $< 1\times10^{100}$ n, r (n and r are integers) $0 \leqq r \leqq n$, $n < 1\times10^{10}$	〃	〃	
Pol (x, y)	$\sqrt{x^2+y^2} < 1\times10^{100}$	〃	〃	

Function	Input range	Internal digits	Accuracy	Notes
Rec (r, θ)	$0 \leqq r < 1 \times 10^{100}$ (DEG) $\lvert\theta\rvert < 9 \times 10^{9}$° (RAD) $\lvert\theta\rvert < 5 \times 10^{7}$ πrad (GRA) $\lvert\theta\rvert < 1 \times 10^{10}$grad	15 digits	As a rule, accuracy is ± 1 at the 12th digit.	However, for tanθ: $\lvert\theta\rvert \neq 90(2n+1)$:DEG $\lvert\theta\rvert \neq \pi/2(2n+1)$:RAD $\lvert\theta\rvert \neq 100(2n+1)$:GRA
°′″	$\lvert a\rvert$, b, $c < 1 \times 10^{100}$ $0 \leqq$ b, c	〃	〃	
← °′″	$\lvert x\rvert < 1 \times 10^{100}$ Hexadecimal display: $\lvert x\rvert \leqq 1 \times 10^{7}$			
^ (x^y)	$x > 0$: $-1 \times 10^{100} < y \log x < 100$ $x = 0$: $y > 0$ $x < 0$: $y = n, \frac{1}{2n+1}$ (n is an integer) However; $-1 \times 10^{100} < \frac{1}{y} \log \lvert x\rvert < 100$	〃	〃	
$\sqrt[x]{y}$	$y > 0$: $x \neq 0$ $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ $y = 0$: $x > 0$ $y < 0$: $x = 2n+1, \frac{1}{n}$ ($n \neq 0$, n is an integer) However; $-1 \times 10^{100} < \frac{1}{x} \log \lvert y\rvert < 100$	〃	〃	
$a^b/_c$	•Results Total of integer, numerator and denominator must be within 10 digits (includes division marks). •Input Result displayed as a fraction for integer when integer, numerator and denominator are less than 1×10^{10}.	〃	〃	
SD (REG)	$\lvert x\rvert < 1 \times 10^{50}$ $\lvert y\rvert < 1 \times 10^{50}$ $\lvert n\rvert < 1 \times 10^{100}$ $x\sigma n$, $y\sigma n$, $\bar{x}$, $\bar{y}$, A, B, r: $n \neq 0$ $x\sigma n-1$, $y\sigma n-1$: $n \neq 0, 1$	〃	〃	

Function	Input range
BASE-N	Values after variable within following range: 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)

*Errors may be cumulative with internal continuous calculations such as ^ (x^y), $\sqrt[x]{y}$, $x!$, $\sqrt[3]{x}$ sometimes affecting accuracy.

Appendix F Specifications

Model: fx-9700GH

Calculations

Basic calculation functions:
Negative numbers, exponents, parenthetical addition/subtraction/multiplication/division (with priority sequence judgement function — true algebraic logic).

Built-in scientific functions:
Trigonometric/inverse trigonometric functions (units of angular measurement: degrees, radians, grads); hyperbolic/inverse hyperbolic functions; logarithmic/exponential functions; reciprocals; factorials; square roots; cube roots; powers; roots; squares; decimal-sexagesimal conversions; permutations/combinations; π; random numbers; internal rounding; fraction functions; engineering and engineering symbol (11 types) calculations; negative signing; exponential notation input; parenthetical calculations; coordinate transformations; number of decimal place and significant digit specification

Differentials: Extraction of derivative using differential from center point.

Integrations: Using Simpson's rule.

Σ Calculations: Calculation of partial sum of sequence $\{a_n\}$

Complex Number Calculations:
Addition, subtraction, multiplication, division, reciprocal, square root, squaring, absolute number/argument calculations; conjugate complex number extraction; real number part/imaginary number part extraction

Statistics:
Standard deviation: number of data; mean; standard deviation (two types); sum; sum of squares; statistical calculation of mode, median, maximum value, minimum value; normal distribution calculation
Regression: number of data; mean of x; mean of y; standard deviation of x (two types); standard deviation of y (two types); sum of x; sum of y; sum of squares of x; sum of squares of y; sum of square of x and y; fixed term; regression coefficient; correlation coefficient; estimated value of x; estimated value of y

Matrix Calculations:
Addition, subtraction, multiplication, division; scalar product; transposed matrix; determinant; matrix inverting; matrix squaring; matrix row operations; dimension specification

Equation Calculations:
Solutions for linear equations with two through six unknowns, quadratic equations, and cubic equations; recall of equation coefficients and solutions

Value memories: 28 standard, expandable up to 2,428

Calculation range:
1×10^{-99} to $9.99999999999 \times 10^{99}$ and 0. Internal operation uses 15-digit mantissa.

Exponential display: Norm 1: $10^{-2} > |x|, |x| \geq 10^{12}$
Norm 2: $10^{-11} > |x|, |x| \geq 10^{12}$

Rounding:
Performed according to the specified number of significant digits and number of specified decimal places.

Graph functions

Built-in function graphs (rectangular and polar coordinates):
(40 types) sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, log, ln, 10^x, e^x, x^2, $\sqrt{\ }$, $\sqrt[3]{\ }$, x^{-1}

Graph types: Rectangular coordinate graphs: $y=f(x)$
Polar coordinate graphs: $r=f(\theta)$
Parametric graphs: $(x, y)=(f(T), g(T))$
Inequality graphs: $(y>f(x),\ y<f(x),\ y\geq f(x),\ y\leq f(x))$
Integral graphs
Probability distribution graphs
Single-variable statistical graphs (bar histograms, line graphs, normal distribution curves)
Paired-variable statistical graphs (regression line, logarithmic regression curve; exponential regression curve; power regression curve)

Graph memory: Graph function storage, editing, selection, drawing, solve (roots, maximum and minimums, y-intercepts, intersect values for two graphs, coordinate values at any point, derivative at any point)

Graph functions:
Range specification; overwrite, trace, plot, line, scroll, zoom, box and factor zoom ($\times$f, $\times 1/\iota$, Original, Adjust, Coordinate rounding) capabilities

Dual Graph:
Range settings for left and right side graphs; graph drawing in main window; copy function; change function

Dynamic Graph:
Storage, editing, selection, drawing of Dynamic Graph functions; variable drawing speed; seven built-in Dynamic Graph functions

Table & Graph:
Input and editing of functions/recursion formulas; value tables; graph drawing; number table delete, insert, append

Programming

Programming:
Input, storing, recall, execution of programs in program area; program editing, insert, delete; storage for up to 38 programs (Prog 0 to 9, Prog A to Z, Prog r, Prog θ)

File Editor:
File name storage, search; program data input, search, execute; file name/program data edit, insert, delete; password function

Program commands: Unconditional jumps: Goto, Lbl
Conditional jumps: $\Rightarrow$, $\blacktriangleleft$, logical operators ($=$, $\neq$, $>$, $<$, $\geq$, $\leq$)
Jumps with count: Isz, Dsz
Subroutine calls: Prog, up to 10 levels of nesting

Number of stored programs: 38 maximum (P0 to P9; PA to PZ; Pr, Pθ)

Check functions: Program checking, debugging

Program area: 24,000 bytes maximum

Program communications

Communication functions:
Communication of all memory contents: programs, file names and File Editor contents, Function Memory contents, Matrix Memory contents, single-variable and paired-variable statistical data, value memory and extended memory contents, graph range parameters, zoom factors, Table & Graph data, graph functions, Dynamic Graph functions, equation coefficient values

Communication method: Start-stop (asynchronous), half-duplex.

Transmission speed: 1200, 2400, 4800, 9600 (BPS)

Parity: Even, odd, none

Bit length: 8 bits

Stop bit:
Send: 2 bits
Receive: 1 bit

General

Display system:
21-character × 8-line liquid crystal display; 12-digit mantissa and 2-digit exponent for calculations; displays binary, octal, hexadecimal, sexagesimal values, fraction, complex number

Power supply: Main: Four AAA-size batteries (LR03 (AM4) or R03 (UM-4))
Memory protection: One CR2032 lithium battery

Power consumption: 0.1W

Battery life Main: Approximately 650 hours with battery type LR03 (AM4)
Approximately 350 hours with battery type R03 (UM-4)
Approximately 2 years (power switch off) with battery type LR03 (AM4)/R03 (UM-4)
Memory protection: Approximately 15 months

Auto power off:
Power is automatically switched off approximately six minutes after last operation except when drawing dynamic graphs.

Ambient temperature range: 0°C ~ 40°C (32°F ~ 104°F)

Dimensions: 20mmH × 85mmW × 172.5mmD ($^3/_4$"H × $3^3/_8$"W × $6^3/_4$"D)

Weight: 218.5g (7.7oz) including batteries

Accessories: Hard case

Q

R

S

T

U

V

X

Y

Z

Key Index

Key	Primary Function	combined with SHIFT	combined with ALPHA
Trace F1	Turns trace function on/off. Selects 1st function menu item.		
Zoom F2	Turns zoom function on. Selects 2nd function menu item.		
Plot F3	Turns plot function on. Selects 3rd function menu item.		
Line F4	Turns line function on. Selects 4th function menu item.		
Cls F5	Clears the graph screen. Selects 5th function menu item.		
Coord F6	Displays graph coordinates. Selects 6th function menu item.		
SHIFT	Activates shift functions of other keys and function menus.		
A-LOCK ALPHA	Allows entry of alphanumeric characters shown in red.	Locks/Unlocks entry of alphanumeric characters.	
QUIT EXIT	Backsteps to the previous menu.	Returns directly to the initial screen of the mode.	
SET UP MENU	Returns to the Main Menu .	Shows the set up display.	
G-$\int dx$: G↔T	Switches display between graph & text screens.	Provides graphic integral solution.	Enters colon.
d/dx r Graph	Activates graph function.	Provides numerical differential solution.	Enters character r.
G-SOLV θ Range	Displays range parameter input screen.	Displays the graph solve menu.	Enters character θ.
CAPA ; M Disp	Displays current mode settings. (press & hold) Transfers screen shot to personal computer.	Press and hold to display remaining memory capacity.	Enters semicolon.
▲	Moves cursor upward. Scrolls screen.	Switches to next function in trace mode.	
▼	Moves cursor downward. Scrolls screen.	Switches to next function in trace mode.	
◀	Moves cursor to left. Scrolls screen. Press after EXE to display calculation from end.		

Key	Primary Function	combined with SHIFT	combined with ALPHA
▶	Moves cursor to right. Scrolls screen. Press after EXE to display calculation from beginning.		
$\int dx$ A X,θ,T	Allows input of variables X, θ, and T.	Provides numerical integral solution.	Enters letter A.
10^x B log	Press before entering value to calculate common logarithm.	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 $a^b/_c$	Press between entering fraction values. Converts fraction to decimal.	Displays improper fraction.	Enters letter G.
√ H x^2	Press after entering value to calculate square.	Press before entering value to calculate square root.	Enters letter H.
$\sqrt[3]{}$ I (	Enter open parenthesis in formula.	Press before entering value to calculate cube root.	Enters letter I.
x^{-1} J)	Enter close parenthesis in formula.	Press after entering value to calculate reciprocol.	Enters letter J.
, K →	Assigns value to a value memory name.	Enters comma.	Enters letter K.
$\sqrt[x]{}$ L ^	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 letter L.
PRGM M 7	Enters number 7.	Displays program command menu.	Enters letter M.
N 8	Enters number 8.		Enters letter N.
O 9	Enters number 9.		Enters letter O.
INS DEL	Deletes character at current cursor location.	Allows insertion of characters at cursor location.	

Key Index

Key	Primary Function	combined with SHIFT	combined with ALPHA
Trace F1	Turns trace function on/off. Selects 1st function menu item.		
Zoom F2	Turns zoom function on. Selects 2nd function menu item.		
Plot F3	Turns plot function on. Selects 3rd function menu item.		
Line F4	Turns line function on. Selects 4th function menu item.		
Cls F5	Clears the graph screen. Selects 5th function menu item.		
Coord F6	Displays graph coordinates. Selects 6th function menu item.		
SHIFT	Activates shift functions of other keys and function menus.		
A-LOCK ALPHA	Allows entry of alphanumeric characters shown in red.	Locks/Unlocks entry of alphanumeric characters.	
QUIT EXIT	Backsteps to the previous menu.	Returns directly to the initial screen of the mode.	
SET UP MENU	Returns to the Main Menu .	Shows the set up display.	
G↔T : G↔T	Switches display between graph & text screens.	Provides graphic integral solution.	Enters colon.
d/dx r Graph	Activates graph function.	Provides numerical differential solution.	Enters character r.
G-SOLV θ Range	Displays range parameter input screen.	Displays the graph solve menu.	Enters character θ.
CAPA ; M Disp	Displays current mode settings. (press & hold) Transfers screen shot to personal computer.	Press and hold to display remaining memory capacity.	Enters semicolon.
▲	Moves cursor upward. Scrolls screen.	Switches to next function in trace mode.	
▼	Moves cursor downward. Scrolls screen.	Switches to next function in trace mode.	
◀	Moves cursor to left. Scrolls screen. Press after EXE to display calculation from end.		

Key	Primary Function	combined with SHIFT	combined with ALPHA
▶	Moves cursor to right. Scrolls screen. Press after EXE to display calculation from beginning.		
$\int dx$ A X,θ,T	Allows input of variables X, θ, and T.	Provides numerical integral solution.	Enters letter A.
10^x B log	Press before entering value to calculate common logarithm.	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 fraction.	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 (	Enter open parenthesis in formula.	Press before entering value to calculate cube root.	Enters letter I.
x^{-1} J)	Enter close parenthesis in formula.	Press after entering value to calculate reciprocol.	Enters letter J.
, K →	Assigns value to a value memory name.	Enters comma.	Enters letter K.
$\sqrt[x]{}$ L ^	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 letter L.
PRGM M 7	Enters number 7.	Displays program command menu.	Enters letter M.
N 8	Enters number 8.		Enters letter N.
O 9	Enters number 9.		Enters letter O.
INS DEL	Deletes character at current cursor location.	Allows insertion of characters at cursor location.	

Key Index

Key	Primary Function	combined with (SHIFT)	combined with (ALPHA)
OFF AC ON	Turns power on. Clears the display.	Turns power off.	
CMPLX P 4	Enters number 4.	Displays the complex number calculation menu.	Enters letter P.
MATH Q 5	Enters number 5.	Display built in function menu.	Enters letter Q.
VAR R 6	Enters number 6.	Displays variable data menu.	Enters letter R.
S ×	Multiplication function.		Enters letter S.
T ÷	Division function.		Enters letter T.
DRG U 1	Enters number 1.	Sets/converts unit of angular measurement.	Enters letter U.
DISP V 2	Enters number 2.	Displays menu of display format choices.	Enters letter V.
CLR W 3	Enters number 3.	Displays memory clear menu.	Enters letter W.
X +	Addition function. Specifies positive value.		Enters letter X.
Y −	Subtraction function. Specifies negative value.		Enters letter Y.
F MEM Z 0	Enters number 0.	Displays function memory menu.	Enters letter Z.
Defm i .	Enters decimal point.	Shows memory status.	Enters open bracket.
π [EXP	Allows entry of exponent.	Inputs value of pi. Enters pi symbol.	Enters close bracket.
Ans SPACE (−)	Enter before value to specify as negative.	Recalls most recent calculation result.	Enters a blank space.
↵ EXE	Displays result of calculation.	Inputs a new line.	

MEMO