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EL-9650 GRAPHING CALCULATOR

SHARP®

SHARP®

MODEL

# EL-9650

## GRAPHING CALCULATOR

OPERATION MANUAL

This equipment complies with the requirements of Directive 89/336/EEC as amended by 93/68/EEC.

Dieses Gerät entspricht den Anforderungen der EG-Richtlinie 89/336/EWG mit Änderung 93/68/EWG.

Ce matériel répond aux exigences contenues dans la directive 89/336/CEE modifiée par la directive 93/68/CEE.

Dit apparaat voldoet aan de eisen van de richtlijn 89/336/EEG, gewijzigd door 93/68/EEG.

Dette udstyr overholder kravene i direktiv nr. 89/336/EEC med tillæg nr. 93/68/EEC.

Quest'apparecchio è conforme ai requisiti della direttiva 89/336/EEC come emendata dalla direttiva 93/68/EEC.

Η εγκατάσταση αυτή ανταποκρίνεται στις απαιτήσεις των οδηγιών της Ευρωπαϊκής Ενωσης 89/336/ΕΟΚ, όπως ο κανονισμός αυτός συμπληρώθηκε από την οδηγία 93/68/ΕΟΚ.

Este equipamento obedece às exigências da directiva 89/336/CEE na sua versão corrigida pela directiva 93/68/CEE.

Este aparato satisface las exigencias de la Directiva 89/336/CEE, modificada por medio de la 93/68/CEE.

Denna utrustning uppfyller kraven enligt riktlinjen 89/336/EEC så som kompletteras av 93/68/EEC.

Dette produktet oppfyller betingelsene i direktivet 89/336/EEC i endringen 93/68/EEC.

Tämä laite täyttää direktiivin 89/336/EEC vaatimukset, jota on muutettu direktiivillä 93/68/EEC.

# INTRODUCTION

Congratulations on purchasing the EL-9650 Graphing Scientific Calculator. Please read this operation manual carefully to familiarize yourself with all the features of the calculator and to ensure years of reliable operation. Also, please keep this operation manual on hand for reference.

## NOTICE

- The material in this manual is supplied without representation or warranty of any kind. SHARP assumes no responsibility and shall have no liability of any kind, consequential or otherwise, from the use of this material.
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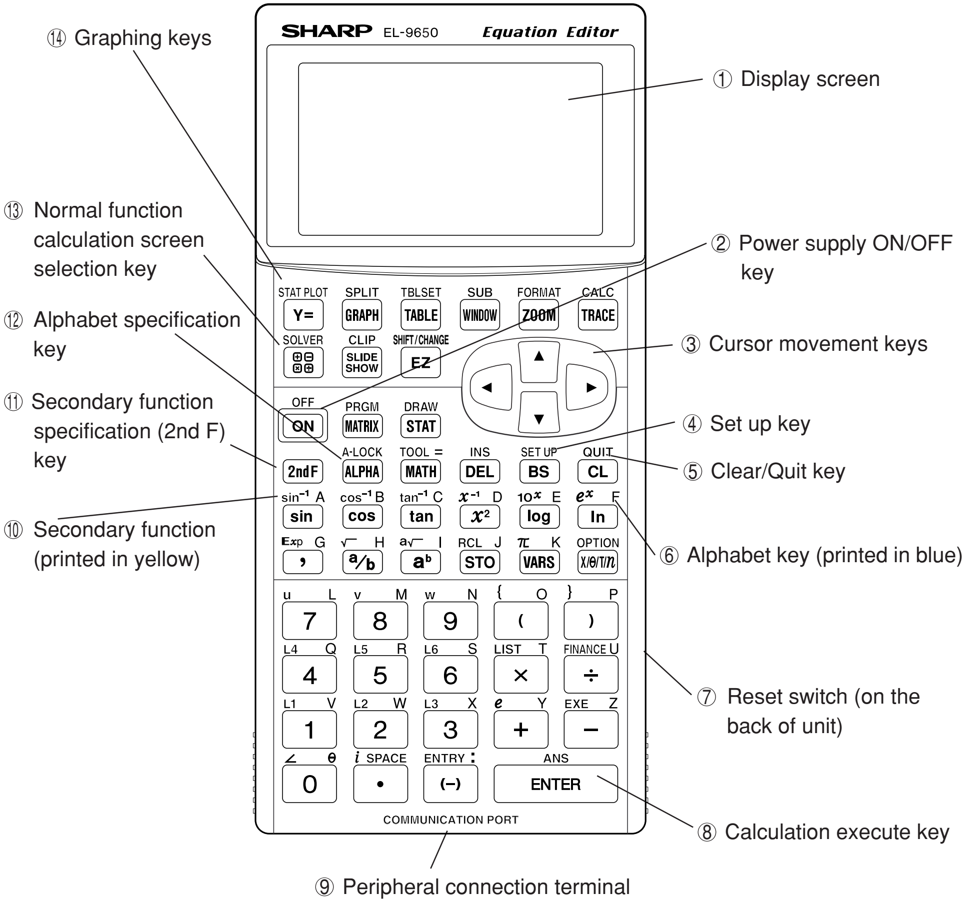
- SHARP assumes no responsibility, directly or indirectly, for financial losses or claims from third persons resulting from the use of this product and any of its functions, the loss of or alteration of stored data, etc.
- The information provided in this manual is subject to change without notice.

# CONTENTS

# GETTING STARTED

## 1. Names of Parts



# 2. Function of Each Part

① **Display screen**

② **Power supply ON/OFF key:** Press ON to turn on the power supply. Press 2ndF OFF/ON to turn off the power supply.

③ **Cursor movement keys:** Specifies location to input/correct characters and numbers. The cursor is indicated using "_" when there is no number or character. The cursor is indicated using a flashing "▨" when overlapping a number or character (this may vary according to setting or display screen). These keys are also used when selecting menus.

④ **Set up key:** Mode setting key that determines the calculation method and display format of this graphing scientific calculator.

⑤ **Clear/Quit key:** Used when clearing numerical values, calculation commands, programs, etc., or when returning to the previous screen. This key is also used when clearing errors.

⑥ **Alphabet key:** Used with ALPHA to enter letters.

⑦ **Reset switch:** Used when replacing batteries or when errors occur. Caution is required since all memory contents will be deleted when pressing the reset switch.

⑧ **Calculation execution key:** Used when specifying calculation commands and executing calculations.

⑨ **Peripheral connection terminal:** Terminal used when connecting separately sold cables or a PC link cable (not a power supply).

⑩ **Secondary function:** Used with 2ndF to input secondary functions.

⑪ **Secondary function specification key:** Used when specifying an operation printed in mustard-yellow above a key (upper left).

⑫ **Alphabet specification key:** Used when specifying an operation printed in blue above a key (upper right).

⑬ **Normal function calculation screen selection key:** Used when selecting the screen which performs numerical calculations or calculations using functions.

⑭ **Graph related keys:**

Various settings for graphing can be made using the group of keys indicated in the box.

- Y=: Used to open the formula input screen for drawing graphs.
- SLIDE SHOW: This function is used for studying graphs and to aid understanding. (For details, see page 221.)
- EZ: Introduces the user to a mode where expansion and reduction of the graphing screen, input of main functions and graphing settings can be performed with ease. (For details, see CHAPTER 4 “15. Useful Functions” on page 124.)
- SHIFT/CHANGE EZ : The user can move graph curves and change formats directly with a touch of a pen (For details, see page 229).
- GRAPH: Draws a graph using the formula inputted in Y=.

# 3. Explanation of Keys

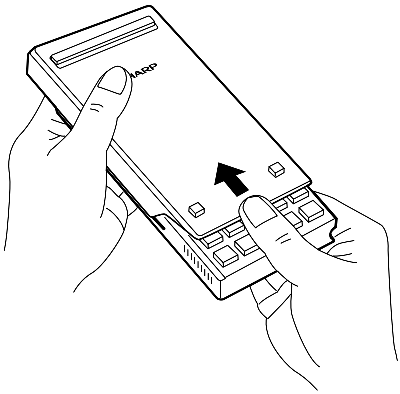
- Most keys have more than two functions.
- To use a function printed on a key, simply press the button.
- To specify a function (secondary function) printed in yellow above a key or on the upper left, press 2ndF first.
- To specify a function a character printed in blue on the upper right side of a key, press the ALPHA key first.
  However, there are exceptions to this rule, as in the Menu selection screen, etc., where ALPHA does not have to be pressed first.

**<Example>**

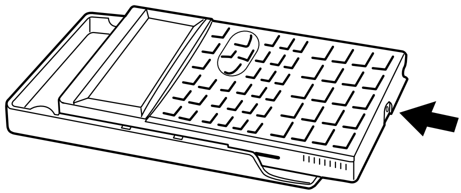
Operation of sin (sin$^{-1}$ A)
- → 2ndF sin$^{-1}$: Specify sin $^{-1}$
- → ALPHA A : Specify character A
- → sin: Specify sin

# 4. Using the Protective Cover

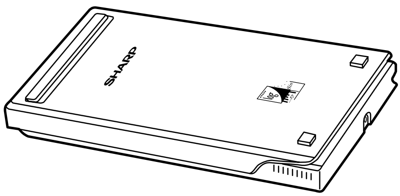
To open the cover:



When in use:



When not in use:



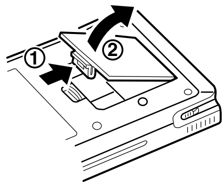

*CAUTION*

Be careful not to drop the touch-pen when removing the unit from its protective cover.

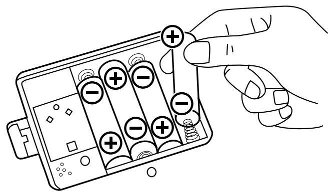
# 5. When Using for the First Time

## (1) Inserting batteries

1. Open the battery cover located on the back of the unit.
   To remove the battery cover, pull down on the tab then lift up.




2. Insert batteries as shown in the diagram to the right.
   Be careful to insert the batteries in the correct direction.

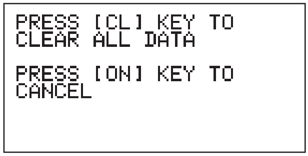


Do not remove the label since it contains backup battery for memory protection.

3. Close the battery cover.
   Make sure that the tab that was pulled when opening the cover is inserted completely and a snapping sound is heard.
   The unit is automatically reset when closing the battery cover. The display “WAIT” will appear while the unit initializes settings.
   Since the cover also functions as a reset switch, power will not turn on unless the cover is attached.

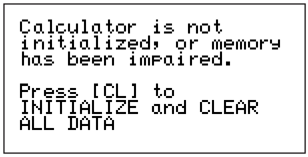
## (2) Resetting the calculator

1. Press the RESET switch located on the back of the unit to clear all data within the calculator's memory.
- A "WAIT" display will appear momentarily when pressing the RESET switch. When the display disappears, the screen shown to the right will appear.
- Press the [CL] key (the display will change to that shown to the right, indicating that all data within the internal memory of the calculator has been cleared).
- Move to the standard function calculation screen by pressing any key.





* The message shown to the right may appear when not performing the above procedure. To prevent loss of data, etc., reset the calculator by following the procedure indicated above.

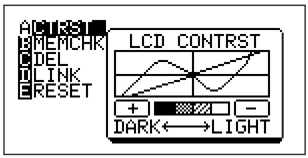



## (3) Adjusting the contrast

Display contrast may vary with the ambient temperature and remaining battery power. Adjust accordingly for the best view.

**Operation:**

1. Press [2ndF] [OPTION].
   The Optional functions menu will appear (see the diagram on the right).
2. The contrast can be adjusted using [+] [−].
   [+] : Increases the contrast
   [−] : Decreases the contrast
3. Press [2ndF] [QUIT] to return to the previous screen.



## (4) Turning the power off

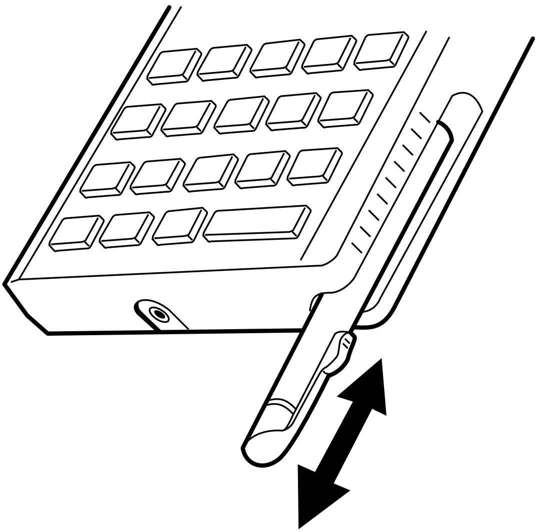
Press [2ndF] [OFF] to turn the power off.

**Regarding the automatic power-off function:**

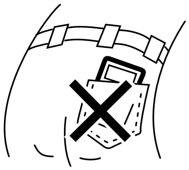
The power supply is automatically turned off when there is no operation for a period of approximately 10 minutes to save battery consumption (the time varies by a few minutes according to use).
This function will not operate while executing calculations (flashing "▨" on the upper right side of the screen).

# 6. Inserting and Removing the Touch-pen

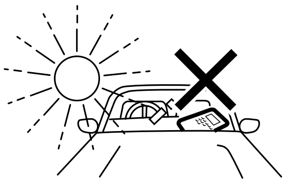
It is possible to store the touch-pen on the side of the main unit when not in use.



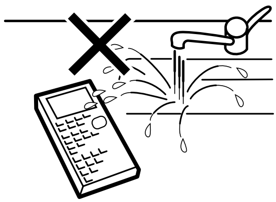
# 7. Caring for Your Calculator



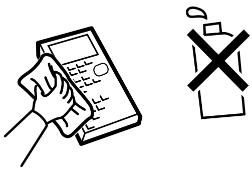
Do not carry the calculator around in your back pocket, as it may break when you sit down. The display is made of glass and is particularly vulnerable.



Keep the calculator away from extreme heat such as on a car dashboard or near a heater, and avoid exposing it to excessively humid or dusty environments.



Since this product is not waterproof, do not use it or store it where fluids, for example water, can splash onto it. Raindrops, water spray, juice, coffee, steam, perspiration, etc. will also cause malfunction.



Clean with a soft, dry cloth using no solvents.

Do not use a sharp pointed object or exert too much force when pressing keys.

Avoid excessive physical stress.

# CHAPTER 1
# GENERAL INFORMATION

This chapter describes the basic key operations (input rules) of the calculator. The procedures described here show how to perform calculations with common math functions. This chapter also explains the main set-up functions (mode settings).

## 1. Entering Numeric Values

The number keys ([0] to [9]), and [·] and [(—)] are used to enter numeric values.

**<Example>**

To enter “356.25”

Press [+−×÷] [CL] 356 [·] 25.

```
356.25_
```

- To enter an exponent, use [2ndF] [Exp].

**<Example>**

To enter “36×10$^{15}$”

Press [+−×÷] [CL] 36 [2ndF] [Exp] 15.

```
36E15_
```

- To enter a negative (-) number, press [(—)] before entering the number.

* Using [−] to enter a negative number generates an error. [−] is used only for subtraction.

**<Example>**

To enter “-25.34”

Press [+−×÷] [CL] [(—)] 25 [·] 34.

```
-25.34_
```

# 2. Common Math Operations

The calculator can be used in the same way as a standard calculator for calculations using common math operations.

**<Example>**

To obtain the answer of "(100+256)×2÷85–9"

Press [CL] [(] 100 [+] 256 [)] [×] 2 [÷] 85 [−] 9.

```
(100+256)*2/85-9
            -.623529411
```

Press [ENTER] to execute the calculation. The result of the calculation appears on the right side of the display below the expression. The display does not include an equal (=) sign.

# 3. Changing Entered Characters and Expressions

To change a character or expression before executing the calculation, follow the procedure below.
Move the cursor to the location for correction. The new content will be inserted to the left of the cursor when entered (during Equation edit mode).

Move the cursor to the character or expression to be changed, and enter a new character or expression. (When the one line edit mode is selected)

- DEL: deletes an entry. When this key is pressed, the character or expression where the cursor is located is deleted.
- BS: moves the cursor backward. Each time BS is pressed, the cursor moves one space to the left and deletes the character or expression entered in that location.
- 2ndF INS : after pressing these keys, a character or expression can be inserted to the left side of the cursor. (When the one line edit mode is selected.)
  - * When the INSERT mode is selected, the cursor changes to the "◀ " symbol.
  - * When the INSERT mode is selected, the mode stays active until 2ndF INS are pressed again. In the equation edit mode (see CHAPTER 1 "11.Edit Modes" on page 25), the INSERT mode automatically becomes active.
- CL : clears an entire expression that has been entered and the result of the previous calculation.

**<Example>**
To change "÷" in the expression "(100+256)×2÷85–9" to, "×".
After entering ( 100 + 256 ) × 2 ÷ 85 − 9 , enter ◀ ◀ ◀ ◀ ◀ DEL × ENTER to make the change.

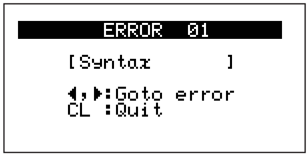
```
(100+256)*2/85-9_
```

```
(100+256)*2*85-9
               60511
```

# 4. Correcting Errors

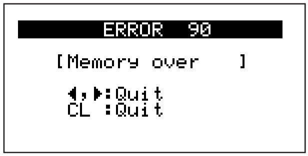
When an error is generated, the calculator displays an error message (examples shown below), and stops operating.
The method of correcting an error varies depending on the error code.

**Example A:** This display indicates that a syntax error has occurred. To correct it, follow the procedure below.




- Use ◀ or ▶ to move the cursor to the error location, and correct error. (The expression on the screen can be changed.)
- Use CL to clear the error. (The display will return to the primary screen. The entered expression will be deleted.)

**Example B:** This display indicates that a memory error has occurred. To correct it, follow the procedure below.




- Use ◀, ▶, or CL to clear the error. (The entered expression will be deleted.)

**Example C:** When any error except one described above occurs, follow the procedure below.

- Use ◀ or ▶ to move the cursor to the error location, and correct error. (The expression on the screen can be changed.)
- The display will vary depending on the error message.

* For the details of error codes and messages, see APPENDIX “3.Error Codes and Error Messages” on page 270.

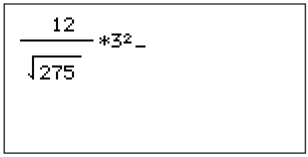
# 5. Using Functions

The following shows an example of a calculation using functions that are directly accessible from the keys (functions indicated on keys and secondary functions).

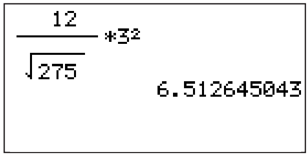
**<Example>**

To obtain the answer of "$\frac{12}{\sqrt{275}} \times 3^2$"

1. Press [⊞] 12 [a/b] [2ndF] [√‾] 275 [▶] [▶] [×] 3 [$x^2$].




2. Press [ENTER].



# 6. Using Secondary Functions (2ndF) and Alphabet Letters (ALPHA)

- The functions and characters printed to the left and right sides above the keys become active for the next keystroke when [2ndF] or [ALPHA] is pressed.
- When [2ndF] is pressed, the functions printed in yellow become active. When [ALPHA] is pressed, the characters printed in blue become active.
- When [2ndF] or [ALPHA] is pressed, the shape of the cursor changes to indicate that the setting has been changed. (See CHAPTER 1 “12.Display Format of the Cursor Pointer” on page 32 for details.)

## (1) Using secondary functions (2ndF)

The secondary functions include function entries, menu screen display, and mode settings.

**<Example>**

To obtain the answer “$\sin^{-1}$ 0.5” (Angle mode: Radian)

Press [2ndF] [$\sin^{-1}$] .5 [ENTER]

↑ Secondary function of “sin” key

```
sin⁻¹ .5
                .523598775
```

## (2) Entering alphabet letters

**<Example>**

To enter “A123BCDθ”

[ALPHA] A 1 2 3 [2ndF] [A-LOCK] B C D θ.

```
A123BCDθA
```

- Press [2ndF] [A-LOCK] to set to the ALPHA LOCK mode. In this mode, alphabet letters can be entered continuously from the keyboard.
- To change from the ALPHA LOCK mode to the normal mode, press [ALPHA] (The cursor changes from “A” to “_”.)

For successful usage, function names, graph equation names (Y1 to Y9 and Y0), list names (L1 to L6) etc., should not be typed out.  Instead, the appropriate key must be pressed or menu item selected.

**<Example>**

To input a graph equation named “Y1”, press [VARS] [A] [ENTER] [A] [1]. Pressing [ALPHA] [Y] [1] will display “Y1” on the screen, but an error will be returned when executing.

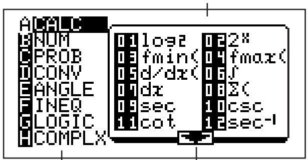
# 7. Using Menus

This calculator is equipped with function menus that allow many functions other than those printed on the keys and main unit to be used. These additional functions are grouped by function type and item type. Calculations and mode settings can be executed by selecting appropriate functions.

**<Example>**

Press [⊞] and [MATH].

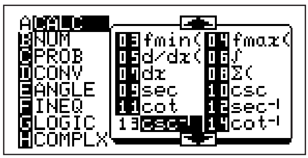
Sub-menu items




Main menu items

[↓] : This symbol appears when there are more items after No. 12.

- The display changes to the screen shown above.
- The main menu lists items A to H (the number of items varies in each menu). Each item on the main menu has a sub-menu.
- On this display, the highlighted function or mode name (not the alphabet letter or number) is currently selected.
  (In the above example, [A CALC] is currently selected. In the [A CALC] sub-menu, however, the number indications are highlighted. This indicates that no function is currently selected. The sub-menu shows items 01 to 12. The " ↓ " symbol indicates that there are more items that are not currently shown on the screen.)
- To see how many items are in the sub-menu, move the cursor from the main menu to the sub-menu, and scroll down the sub-menu.
  In the example above, press [▶] to move the cursor to the sub-menu side, and press [▼] [▼] [▼] [▼] [▼] [▼] (6 times). The display should look like the one shown on the right (items 01 and 02 disappear from the display, and items 13 and 14 appear at the bottom).

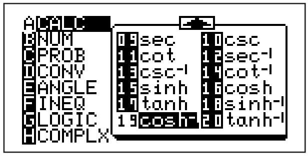


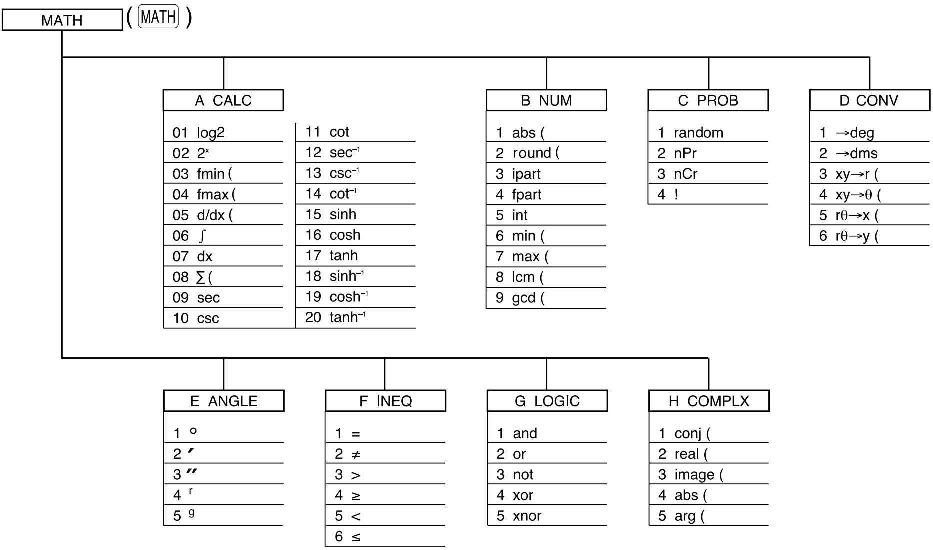

  Press [2ndF] [▼], [ALPHA] [▼] or touch [↓] on the screen with the touch-pen to advance the sub-menu screen.

- " ▲ " and " ▼ " symbols indicate that there are more items before and after those currently shown on the display.
- Press ▼ ▼ ▼ (3 times). The display should look like the one shown on the right.

  When the screen no longer shows the " ▼ " symbol but displays the " ▲ " symbol, there are no more sub-menu items below (end of the page). (There are 20 sub-menu items in the [A CALC] menu.)

  The following diagram shows the main menu and sub-menu structure described above.




There are three ways to select a menu.

① Use ◀, ▶, ▼, and ▲, to move the cursor and highlight the selected function, and press ENTER.

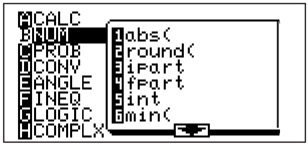
② Enter the letter (A, B, etc.) or number of the selected menu to directly access the menu. (There is no need to press ALPHA.)

③ Select a menu item by pressing the item on the screen twice with the tip of the touch-pen provided.

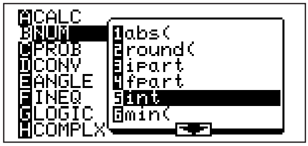
**<Example>**

To use the “int” function to obtain a whole number (The “int” function is in the [B NUM] sub-menu of the MATH menu.)

1. Press MATH to open the MATH menu.
2. Press B (or select [B NUM] using ▼ or the touch-pen).




3. Press ► ▼ ▼ ▼ ▼ (or press 5, or select [5 int] with the touch-pen).

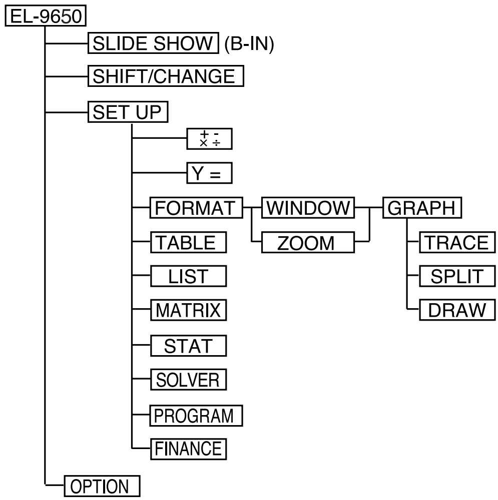



4. Press ENTER, or select [5 int] with the touch-pen again.
   The “int” indication appears on the screen that was displayed before the menu screen appeared.
   * ENTER is not necessary when pressing 5 of procedure 3.
   * In this calculator, functions are grouped and stored in menus. This allows the many functions to be used easily.

# 8. Operating Modes

- The EL-9650 has many modes and commands that are related to the display method of equations, graphs, lists, calculation results and key input
- Expected results cannot be obtained when errors are made in the default settings.
- Modes that influence various calculations and processes have been organized into a flow chart.

* In reality, each command and mode are related in a complex manner.
For example, Y= (equation input) and GRAPH are related. However a vertical line is not drawn on the flow chart.
This is to show the horizontal relationship (modes that have the most influence) in the most simple way.




To view the flow chart:

- SLIDE SHOW is unrelated to the SET UP menu.
- The normal function calculation mode +-×÷ is influenced heavily by the SET UP settings.
- The style of GRAPH, in addition to SET UP is influenced by FORMAT.
- If display or calculation results are not what is expected, check to see whether there are errors in the setting by following the chart to the left.

# 9. Precedence of Calculations

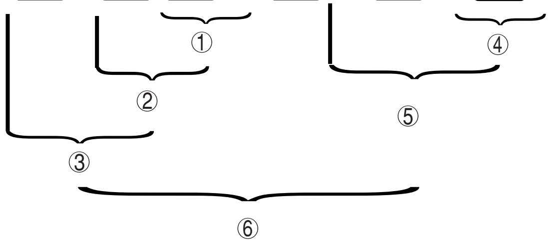
- This unit is equipped with a function that detects calculation precedence.
- The calculation precedence is as follows:

① Fraction calculations (a/b)
② Complex angles (∠)
③ Single calculation functions immediately before a numerical value ($X^2$, $X^{-1}$, !, °, $^r$, $^g$).
④ Exponential functions ($a^b$, $\sqrt[a]{\ }$ etc.)
⑤ Multiplications with omitted “×” commands immediately before variables such as π or stored memory and 2π, 2A, etc.
⑥ Single calculation functions that are irnmediately after a numerical value (sin, cos, tan, $\sin^{-1}$,$\cos^{-1}$, $\tan^{-1}$, log, $10^x$,In, $e^x$, $\sqrt{\ }$ ,abs, int, ipart, fpart, (–), not, neg etc.).
⑦ Multiplication with omitted “×” commands immediately before a single calculation function that follows a numerical value (3 cos 20, etc.).
⑧ Permutation/combined functions (nPr, nCr)
⑨ ×, ÷
⑩ +, –
⑪ and
⑫ or, xor, xnor
⑬ <, ≦, >, ≧, ≠, =, → deg, → dms, etc.
⑭ )
⑮ (
⑯ }, ]
⑰ {, [, STO, etc.

**<Example>**

The key operation and calculation precedence of 5 + 2 × sin 30 + 25 × $5^3$ =

5 [+] 2 [×] [sin] 30 [+] 25 [×] 5 [$a^b$] 3 [ENTER]



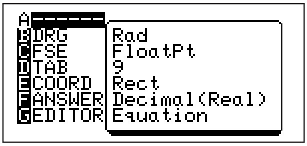
# 10. SET UP Menu

- SET UP is a function that sets input and display methods.
- Please select each method according to use.
- Be sure to set the SET UP mode according to desired calculations and graph plotting since there may be differences in the results depending on the set conditions of SET UP.

## (1) Checking SET UP contents

Press [2ndF] [SET UP].

Contents displayed on the right side of the screen when selecting [A] are the current settings.




* "A" is highlighted and current settings are displayed when entering the SET UP mode. In this case, it is not necessary to press [A].

## (2) SET UP menu

The above display will appear when [2ndF] [SET UP] are pressed. Since item A of the main menu is used for displaying the current settings, the menus that can be set are B through G, with sub-menus for each. The functions of these are explained below.

**[B DRG]:** Used to set the angle unit (default setting: Rad)

[1 Deg]: Set to degree
[2 Rad]: Set to radian
[3 Grad]: Set to gradient

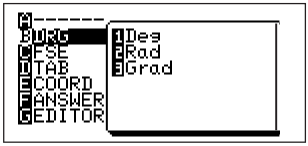
The relationships are: $\underset{\text{Deg}}{90(°)} = \underset{\text{Rad}}{\frac{\pi}{2}\,(\text{Rad})} = \underset{\text{Grad}}{100\,(\text{g})}$

The units of angle are according to the ones chosen in the SET UP. Be careful since the calculation results may differ unless the angle units are set properly.

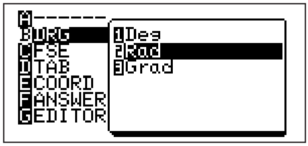
**<Example>**

Calculate “sin π/4” using the Rad mode.

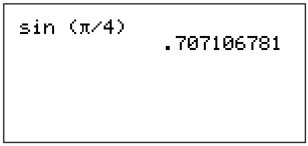
1. Press CL.
   Delete the display screen completely.
2. Press 2ndF SET UP.




3. Press B or touch the [B DRG] display using the touch-pen.
4. Press 2 or touch the [2 RAD].
   Now the Rad mode is set. (When you set for the first time, Rad is already highlighted when moving the cursor pointer from the main menu to the sub-menu. This is because Rad is the default setting.)

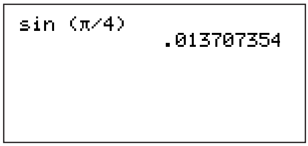



5. Return to the normal function calculation screen by pressing or CL CL.
6. Press sin ( 2ndF π ÷ 4 ) ENTER.




Now try the same calculation in the Deg mode.

1. Press 2ndF SET UP.
2. Press B or touch the [B DRG] display using the touch-pen.
3. Press 1 or touch the [1 Deg] twice.
   Now the Deg mode is set.
4. Return to the normal function calculation screen by pressing , 2ndF QUIT, or CL CL.
5. Press sin ( 2ndF π ÷ 4 ) ENTER.




As can be seen above, the results vary according to the set up, even when performing identical calculations.

**[C FSE]:** Used to set the display method of calculation results (default setting: FloatPt)
[1 FloatPt]: Floating point method
[2 Fix]: Fixed decimal point method
[3 Sci]: Exponential method (∗∗∗E∗∗)
[4 Eng]: Engineer's exponential method (exponentials are in multiples of 3: ∗∗∗E∗∗)
multiples of 3

In [2 Fix], [3 Sci], and [4 Eng], the answer displays using the number of decimals set by TAB.

*CAUTION*

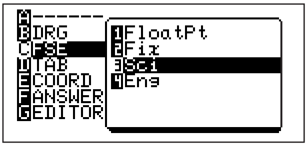
When FloatPt is selected in this menu, FloatPt is given priority even if the number of decimals is specified in [D TAB], which is described later.

**[D TAB]:** Specifies the number of decimals (default setting: 9).
TAB 0 to 9 can be set from submenu options.

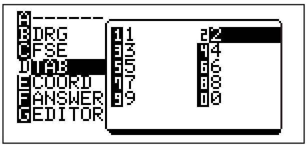
**<Example>**

Set to TAB 2 in the Sci mode then execute "1 ÷ 3".

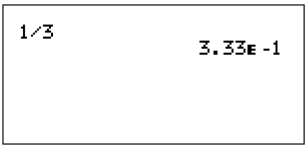
1. Press CL.
   Clear the display screen completely.
2. Press 2ndF SET UP.
3. Press C or touch [C FSE] using the touch-pen.
4. Touch [3 Sci].
   Now the method for displaying results is set.
5. Press D or touch [D TAB].




6. Touch [2 2].
7. Return to the normal function calculation screen by pressing .




8. Press 1 ÷ 3 ENTER.




**[E COORD]**: Used to set the coordinate system of graphs (default setting: Rect)
[1 Rect]: Rectangular coordinates
[2 Param]: Parametric equation coordinates
[3 Polar]: Polar coordinates
[4 Seq]: Sequential graph coordinates

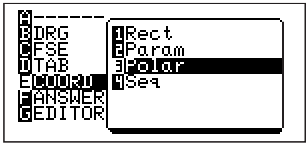
**<Example>**

This example shows the difference of the formula input screen for polar coordinates and rectangular coordinates.

1. Press CL .
2. Press Y= . (Keys to be used when inserting functions or writing subsequent details.)
3. Press 2ndF SET UP .


Formula input screen of rectangular coordinates

4. Press E or touch [E COORD] with the touch-pen.
5. Touch [3 Polar].




6. When Y= is pressed, the formula input screen to the right for polar coordinate graphs will appear. Even with an identical key (Y=), the unit will produce different screens according to the SET UP settings.


**[F ANSWER]**: Used to set the display method and mode of results (default setting: Decimal Real)

| | |
|---|---|
| [1 Decimal] (real): | Displays results using decimals (real number mode). |
| [2 Mixed] (real): | Displays results using mixed fractions (real number mode). |
| [3 Improp] (real): | Displays results using improper fractions (real number mode). |
| [4 x±yi] (complex): | Displays results using complex rectangular numbers (complex number mode). |
| [5 r ∠ θ] (complex): | Displays results using complex polar numbers (complex number mode). |

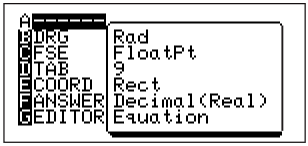
**<Example>**

This example shows the differences in the display method of results for decimals and improper fractions using “1 / 3”.

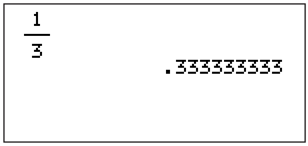
*NOTE*

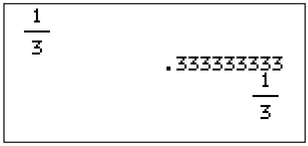
The SET UP condition for B to E is Rad, FloatPt, 9, and Rect respectively.

1. [2ndF] [SET UP] (Check that [F ANSWER] is set to decimal (real).)




2. Press [+−×÷] [CL] 1 [a/b] 3 [ENTER].
3. Press [2ndF] [SET UP].
4. Press [F] or touch [F ANSWER] with the touch-pen.
5. Press [3] or touch [3 Improp] (real) twice.
6. Return to the normal function calculation screen by pressing [+−×÷]. The answer is shown using fractions as in the formula.




**[G EDITOR]**: Used to set the input method of numerical formulas (default setting: Equation).

[1 Equation]: Used to set to the mode where formulas can be input as they appear.

[2 One line]: Used to set to the mode where the input numbers can be input and displayed on one line.

# 11. Edit Modes

Expressions can be entered either by the one-line input method or the equation input method.
In the one-line edit mode, the EL-9650 is used in the same way as a standard scientific calculator. The equation edit mode allows entries of fractions and functions such as powers, roots and constants in a straightforward sequence. (Matrices cannot be entered in a straightforward sequence.)
To set a mode, select : [Equation] (equation edit mode) or [One line] (one-line edit mode) by using [G EDITOR] of the SET UP function.
If an expression has been already entered and is displayed, the expression cannot be changed by switching the input mode.
(If the EDITOR setting is changed in the middle of entering an expression, the portion of the expression that has been entered will be deleted.)

* The calculation speed of the equation edit mode is slower than that of the one-line edit mode due to extra internal processing.

## (1) Equation edit mode

Expressions are displayed two-dimensionally in commonly used mathematical expressions.
In the equation edit mode, expressions up to 114 bytes can be entered and the display shows up to 8 lines of an expression and a calculation result. (It is not possible to input an expression exceeding this limit.)

In the equation edit mode, each key input is displayed after the calculator completes the internal processing to locate the display position of the variable or function. Therefore, the calculation speed is slightly slower. The calculator memory retains a maximum of three keystrokes. Therefore, keys may be operated before the input of the previous keystroke is displayed on the screen. (The screen may display several entries all at once.)

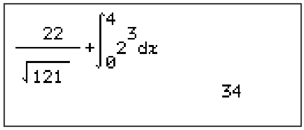
To enter an expression, use number keys, arithmetic keys, other function keys and cursor keys (◀ ▶ ▼ ▲).
The following functions are displayed two-dimensionally on the display.
a/b, $\sqrt[a]{\ }$, $\sqrt{\ }$, $e^x$, $10^x$, $x^2$, $x^{-1}$, $a^b$, abs, $\int dx$ (integral function), ( ), [ ], etc.

Of these, the sizes of the parentheses ( ) and brackets [ ] will be changed depending on the equation.
The sizes of other function indications are the same as those displayed in the one-line edit mode.

**<Example>**

To obtain the answer of " $\frac{22}{\sqrt{121}}+\int_0^4 2^3 dx$ "

1. Press [2ndF] [SET UP] [G] [1] to set to the equation edit mode.
2. Press [CL] to return to the primary screen.
3. Press 22 [a/b] [2ndF] [√] 121 [▶] [▶] [+] [MATH] [A] [0] [6] 0 [▲] 4 [▶] 2 [a^b] 3 [▶] [MATH] [0] [7] [ENTER].



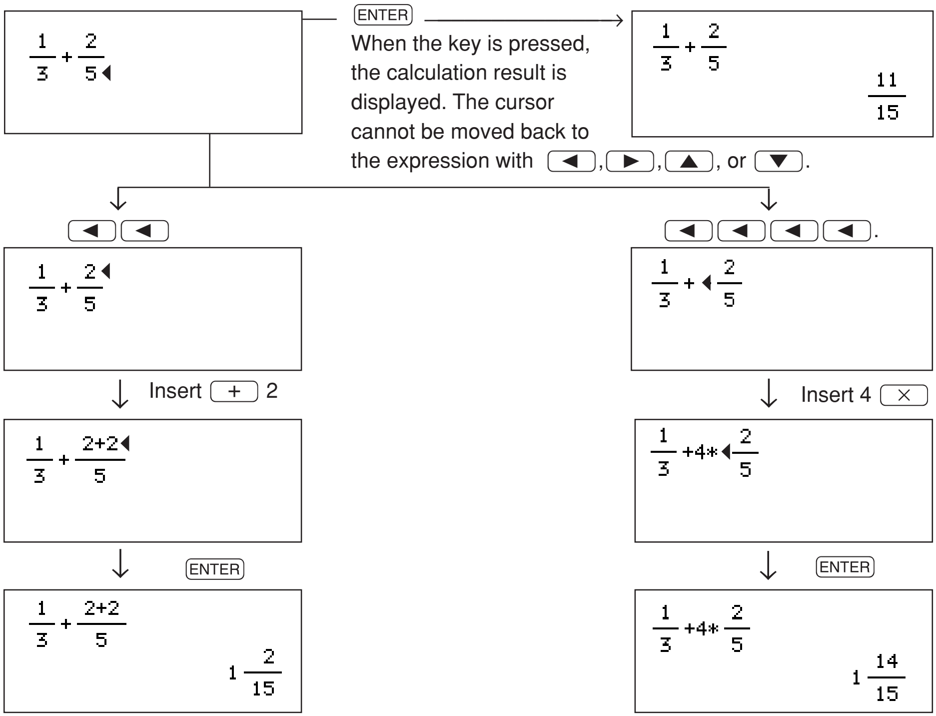

- If the entered expression has more than 22 characters, the screen scrolls to the left.
- In the equation edit mode, the INSERT mode automatically becomes active for key entries. (There is no need to press [2ndF] [INS] to set to the INSERT mode.)
- Use [DEL] or [BS] to delete a function or character.
- When entering a new expression or making a correction, the cursor changes into one of the following four types depending on the input position.
  "_": Indicates the location where a new entry can be made. (Blank space on the right of the cursor)
  " ◀ ": Cursor that appears when inserting. Insertions of text and functions are made to the left of the cursor (flashing).
  " ▨ ": Indicates a cursor that allows insertion of a character or function. The inserted character or function appears on the left side of the cursor. This input cursor appears in front of a structural function or after an argument.  The cursor also appears in front of an expression.
  " □ ": This indication is always accompanied by the " ▨ " cursor, and indicates the input location. It appears after the fraction key [a/b] or power key, etc. is pressed. It indicates the location where the next number or function is to be entered.

**<Example>**

To enter the expression " $\frac{1}{3}+\frac{2}{5}$ ", and move the cursor.

(SET UP F and G setting: Mixed (Real) and Equation)

Press [⊞] [CL] 1 [a/b] 3 [▶] [+] 2 [a/b] 5.



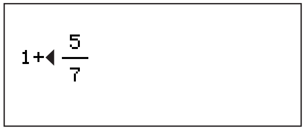
**<Example>**

Here, we will input "$\frac{5}{7}$" first and then "$3+\frac{\sqrt{7}}{5}$", and move the cursor.

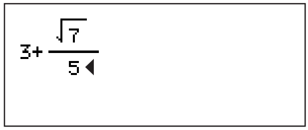
1. Press CL 5 a/b 7.


2. Press ◄ ◄ ◄ ◄.

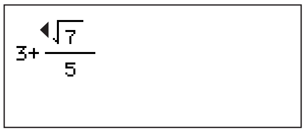

3. Press 1 +.
   "1+" is inserted.



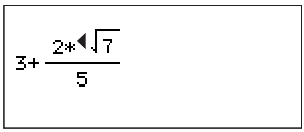

4. Press CL 3 + 2ndF √
   7 ► a/b 5.




5. Press ◄ ◄ ◄ ◄ ◄.




6. Press 2 ×.
   "2×" is inserted.



- Parentheses are automatically placed when inputting structured functions such as $x^2$, $x^{-1}$, $a^b$, etc. (with the exception of abs).

The following eight types of functions are enclosed within parentheses: a/b, $\sqrt[a]{\ }$, $\sqrt{\ }$, $e^x$, $x^2$, $x^{-1}$, $a^b$, $\int dx$ (integral functions)

**<Example>**

Press [CL] 1 [+] 5 [a/b] 6 [▶].

$1+\frac{5}{6}$_

Input [$x^2$]

$1+\left(\frac{5}{6}\right)^2$_

These parentheses are automatically placed.

Press [CL] 1 [+] 2 [◀].

1+2

Input [a/b]

$1+\frac{\square}{2}$

Press [CL] 1 [+] 52 [◀].

1+52

Input [a/b]

$1+\frac{5}{2}$

" □ " will appear for temporary use when there are no arguments.
" □ " will automatically disappear if an argument is added.

$\int_{\blacksquare}^{\square}$

All arguments are displayed with " □ " as in the diagram on the right when inputting integrals (∫). " □ " will also disappear if an argument is input.

Examples for inputting structured functions are shown below. For all other functions, the operation will be the same as the one line input method.

| | |
|---|---|
| ① a / b: 5 [a/b] 2 [▶] | $\frac{5}{2}$ _ |
| ② $\sqrt[a]{\ }$ : 3 [2ndF] [$\sqrt[a]{\ }$] 1 2 1 [▶] | $\sqrt[3]{121}$ _ |
| ③ $\sqrt{\ }$ : [2ndF] [$\sqrt{\ }$] 2 6 [▶] | $\sqrt{26}$ _ |
| ④ $a^b$ : 5 6 [$a^b$] 3 [▶] | $56^3$ _ |
| ⑤ $e^x$ : [2ndF] [$e^x$] 2 [▶] | $e^2$ _ |
| ⑥ $10^x$ : [2ndF] [$10^x$] 5 [▶] | $10^5$ _ |
| ⑦ abs : [MATH] [B] [1] [(−)] 3 6 [▶] | \|-36\| _ |
| ⑧ $\int dx$ (integral) : [MATH] [A] [0] [6] 0 [▲] 3 [▶] 5 [MATH] [A] [0] [7] | $\int_0^3 5dx$ _ |

## (2) One-line edit mode

Expressions are entered with number keys, common math function keys and other function keys in the same manner as with a standard calculator.
The screen displays a maximum of eight lines for an expression and a calculation result. Expressions up to 160 bytes can be entered. Only a limited number of digits and signs are displayed.

**<Example>**

To obtain the answer of “ $\sqrt{\frac{32}{\sqrt[3]{246}}}+3^3$ ” (SET UP B to F settings: Deg, Float Pt, 0, Rect, and Decimal(Real))

1. Press [2ndF] [SET UP] [G] [2] to set to the one-line edit mode.
   * The settings can also be made from the menu by using the cursor keys ( [◀] [▶] [▼] [▲] ) or pen touch.
2. Return the display to the primary screen by pressing [CL].
3. Press [2ndF] [√] [(] 3 2 [a/b] [(] 3 [2ndF] [a√] 2 4 6 [)] [)] [+] 3 [a^b] 3 [ENTER].

```
√(32r(3x√246))+3^3
          29.25988222
```

Each line can contain up to 22 digits and signs. The portion of an entry that exceeds this limit will be displayed from the beginning of the next line.
See CHAPTER 3 on page 49 for the method of entering functions.

# 12. Display Format of the Cursor Pointer

- The display format for the cursor pointer depends on the mode settings and screens, even when performing the same operations.
- The conditions and display formats are as follows:

| | Whole character | | | ④ Half-character |
|---|---|---|---|---|
| | ① Normal input | ② Edit | ③ Insert | |
| Normal | – | ▨ | ◀ | ▮ |
| When pressing ALPHA | A | A | A | |
| When pressing 2nd F | 2 | 2 | 2 | 2 |

① : Cursor that appears during the normal function calculation mode and input screen, MATRIX screen, etc.

② : The cursor of ① will change to this flashing cursor when entering the numerical formula edit mode.

③ : The flashing insert cursor appears when entering the insert mode by pressing the INS while editing numerical formulas (insertions are made to the left of the cursor).

④ : This cursor appears while editing numerical formulas that have been input as is. It is a flashing inset cursor that appears at the end of arguments and in front of structured functions.

- A different cursor may appear on the graphing screen.

# 13. Moving the Cursor

## (1) Moving the cursor horizontally ([◄][►])

The cursor can be moved along the input line. It is also possible to switch from the main menu to the sub-menu and vice versa in the menu screen. The cursor moves one digit at a time for numbers and characters. It is possible to move the cursor along the graph line in the graph display screen during the tracing.

## (2) Moving the cursor vertically ([▲][▼])

When in the one line input mode, it is possible to move the cursor vertically when there are two lines or more. In the input screen for as is formulas, it is possible to move the cursor between arguments of fractions, exponents, and integral functions. It is also possible to move the cursor vertically in the main menu and sub-menu of the menu screen.

## (3) Jumping ([2ndF][◄], [2ndF][►], [2ndF][▲], [2ndF][▼])

It is possible to jump to the top line or the end by pressing [2ndF] before using the cursor movement keys.

Press [2ndF] [◄] to jump to the front of the numerical formula.
Press [2ndF] [►] to jump to the end of the numerical formula.
Press [2ndF] [▲] to jump to the top item of the main menu or sub-menu.
Press [2ndF] [▼] to jump to the last item of the main menu or sub-menu.

* Press [ALPHA] [▲] to jump to the previous page of the sub-menu.
* Press [ALPHA] [▼] to jump to the next page of the sub-menu.

# 14. Resetting the Calculator

## (1) Reset

- Use the reset function in case a malfunction occurs, if you want to delete all data, or want the values for various modes to return to the default settings.
- You can either press the reset switch located on the back of the unit or select the reset function in the menu.

* Take care since resetting the unit will delete all memory data.

## (2) Using the reset switch

The reset switch is located on the back of the unit.

1. Press the reset switch on the set screen.

* Use the enclosed touch pen to press the reset switch. Do not use sharp points such as mechanical pencils, as this may damage the switch.

2. The screen shown on the right will appear. This display will appear after “WAIT” appears momentarily.
3. To clear all memory data, press [CL].

```
PRESS [CL] KEY TO
CLEAR ALL DATA
PRESS [ON] KEY TO
CANCEL
```

Pressing any key will move on to normal function calculation screen.

```
 ALL DATA CLEARED

PRESS ANY KEY
```

- To cancel the reset operation , press [ON].

```
_
```

## (3) Select RESET from the menu

This reset function is used when deleting all memory data at one time or when initializing settings with memory undeleted (SET UP setting contents, etc.).

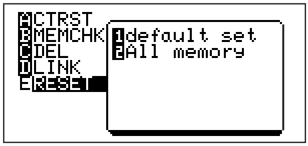
There are two types of resetting:

default set: This reset function initializes only the settings, but does not delete the memory.

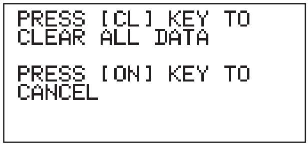
All memory: This reset function initializes the memory contents and settings.

### Deletion of all set memory:

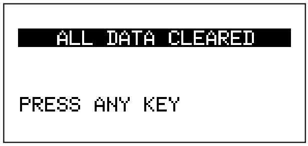
1. Press 2ndF OPTION E.




2. Press 2.

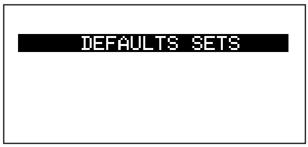



3. Press CL.
   Press any key to return to the normal function calculation screen.




### Initializing settings:

1. Press 2ndF OPTION E 1.
2. Press ENTER.



# CHAPTER 2
# UNIQUE FUNCTIONS

This section explains the unique functions of the EL-9650.

- Pen-touch Operations
- Solver Function (For details, see CHAPTER 9 on page 211.)
- SLIDE SHOW Functions (For details, see CHAPTER 10 on page 221.)
- SHIFT/CHANGE Functions (For details, see CHAPTER 11 on page 229.)

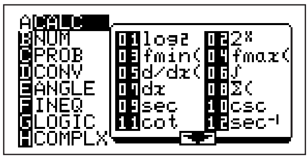
## 1. Pen-touch Operations

- This function allows operations identical with manual key entry, such as selecting menus, changing screens, moving the trace cursor, etc. by touching the screen with the attached pen.
- This function is valid for most screens; however, this function will not operate on some screens.

### (1) Using the touch-pen on the menu screen

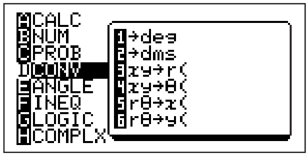
1. Press ON.
   (Manual key entry must always be used for turning on the power supply).
2. Press MATH.
   [A CALC] of the main menu will be highlighted and options 01 to 12 of CALC will appear on the right side of the screen (" ↓ " on the bottom of the screen indicates that there are more sub-menu items after number 12).
   The highlighted menu is the selected menu.

Ⓐ



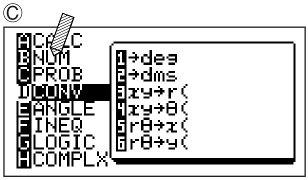
3. Touch [D CONV] of the main menu using the attached pen.
   Check to see that the screen changes to that shown on the right
   ([D CONV] is highlighted, and sub-menu items of [D CONV] are shown on the right).

Ⓑ

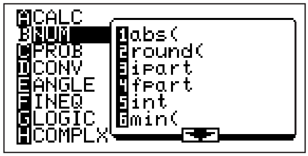



4. Next, touch [B NUM].
   The screen will change to that on the right.

Ⓒ

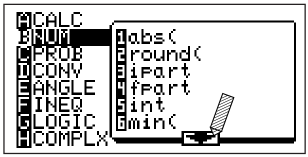



Ⓓ




5. Touch [↓].
   ( [↓] indicates that there are more sub-menu items following number 6.)

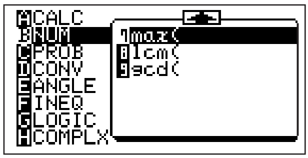
Ⓓ'




6. The screen will change to that shown on the right. Sub-menu items 7 to 9 will be displayed. [↓] will disappear and [↑] will appear on the upper right side of the screen.
   ([↑] indicates that there are more menus before this screen.)

* In other words, pressing [↓] advances the sub-menu by one page (although the [▼] advances one line at a time, specifying [↓] using the touch-pen is equivalent to [ALPHA] [▼] of manual entry. The secondary screen will display sub-menu items 4 - 9 when [2ndF] [▼] is pressed).

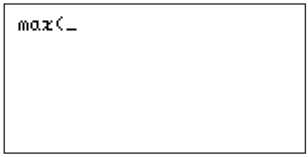
Ⓓ”




7. The highlighted [7 max(] shows that it has been selected.
   To confirm the [7 max(] command, touch the highlight again.

8. The screen will return to the display it had before opening the MATH menu and the previously selected command is transferred.
   (For manual key entry, press ENTER when [7 max(] is highlighted.)

Ⓕ




When performing touch-pen operations in the menu screen such as above, the first pen-touch highlights the selection (indicates that the item has been selected) and the second pen-touch confirms the selection/function for transferring commands to the previous screen or executing calculations.

MATH

D ........................ D ............................................ Pen-touch [D CONV] ..... ScreenⒷ

B ........................ B ............................................ Pen-touch [B NUM] ........ ScreenⒹ

► ALPHA ▼ .... ► ▼ ▼ ▼ ▼ ▼ ▼ ..... * Pen-touch ⬇ ........... ScreenⒹ"

ENTER ...................... ENTER ............................................ Pen-touch [7 max(] ........ ScreenⒻ

* The screen is not exactly the same as others.

## Cautions when using the touch-pen operation:

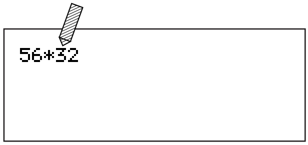
- The touch-pen operation should be performed without exerting force.
- The display screen is made of glass and film and may break if too much force is applied.
- Always use the attached touch-pen when using the touch-pen operation. Using metal or sharp objects will scratch the screen and may result in malfunctions.
- Because there will be a minor difference in the actual display area and the touch area depending on the viewing angle and operating conditions if you make an error, follow the procedure below:
  Since highlighted items are not confirmed, they can be corrected by simply pen-touching the correct item.
  If an item has been confirmed by pressing ENTER, delete the confirmed command by pressing CL, then reenter.

## (2) Using the touch-pen on the normal function calculation screen

**<Example>**

The touch-pen operation for changing the "3" of entered "56 × 32" to "4" is explained here.

1. Initialize the screen.
   Press ⊞ CL .
2. Input 5 , 6 , × , 3 , 2 using manual key entry.
3. Touch "3" on the screen using the pen.
   The cursor will flash on top of the "3" indicating the edit mode (it is now possible to correct the "3") as shown to the right.



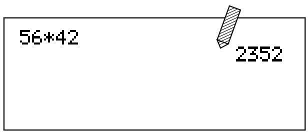

4. Press DEL 4 .


5. "56×42" will be calculated when pressing ENTER .


**<Example>**

The touch-pen operation for changing "56×42", which has completed calculation of "56×42 = 2352", to "36×42" is explained here.

1. Touch the area above the answer (2352 on the diagram to the right) with the touch-pen.



2. This will display the previous formula one line below the answer (the cursor is positioned in a location before the calculation).

```
56*42
                    2352
56*42_
```

3. Select “5” using the touch-pen as above. Change the number to “3” then press ENTER to execute calculation.

```
56*42
                    2352
36*42
                    1512
```

In other words, when a calculation has already been executed, it is possible to call out the formula by touching the area above the answer with the touch-pen.

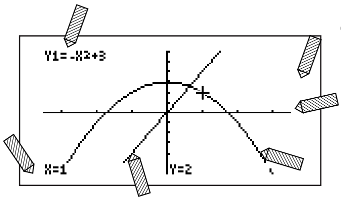
## (3) Using the touch-pen on the graph screen

- In the graph screen, it is possible to easily set the direction and amount of graph shifting using the SHIFT/CHANGE function, etc. as described later, specify tracing locations, and enlarge and reduce screens using the touch-pen operation.
- The selected area when pen-touching on the graph screen is displayed using “[ ]”.
- “[ ]” appears when touching the graph screen with the touch-pen as on the normal function calculation screen, and touching the same area once more confirms the selection.
- The touch-pen is used on the graph screen to specify cursor location (also used to select formulas when tracing).

① Pen-touch the numerical formula

② Pen-touch an area unrelated to graphs or formulas

⑥ Pen-touch the cursor coordinates display




③ Pen-touch the X or Y axis

④ Pen-touch the graph curve (formula display graph)

⑤ Pen-touch the graph curve (no formula display)

- Pen-touching on a full screen graph, as above, is considered here.

* Operations differ when in the normal mode and trace mode. Both are explained below.

* For more information on graphing functions see CHAPTER 4 on page 79.

### When the graph is in the normal mode (non-trace mode):

- ② to ⑤: Press anywhere and “[ ]” will appear with the first pen-touch.
- The cursor pointer will appear in a point (fixed)* within “[ ]” with the second pen-touch to the same area.
- When not in the trace mode, it is possible to display and move the cursor pointer to the specified location for all selections.

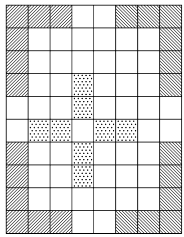
### When the graph is in the trace mode:

① to ③, ⑥: “[ ]” will appear with the first pen-touch.
Touching within “[ ]” deletes “[ ]” and returns to the previous graph mode.

④: “[ ]” will appear with the first pen-touch.
Touching within the “[ ]” moves and displays the cursor pointer within the “[ ]” and the “[ ]” disappears.

⑤: When using the same procedure as in ④, the formula displayed on the upper left along with the cursor movement will change to that of the graph line newly moved by the cursor pointer.

* The location where the cursor pointer appears. The onscreen “[ ]” is displayed using a 8 × 10 dot configuration. The relationship of the cursor pointer and the “[ ]” when pen-touching the second time is fixed as shown below (“▨” is the boxed area and “░” is the cursor pointer).



- Since the split screen (2ndF SPLIT) is always in the trace mode, pen-touching the left side of the screen (graph) moves the cursor in the same manner as the previously-mentioned trace mode. Pen-touching the right side of the screen (list screen or formula screen) changes graph formulas and moves the cursor pointer to the graph curve position that corresponds to the list position.

## (4) Using the touch-pen on other screens

- Pen-touch input is valid for most screens not mentioned previously, such as the menu screen, normal function calculation screen and graph screen.
- On screens similar to that of the menu screen (screens that require selection of set window modes such as Rapid zoom, etc.), list correction, etc., pen-touching will highlight the selected item as with main screen selection method. Other operations are executed in a similar manner to that of the normal function calculation screen.
- You can select the easiest procedure for each screen, since pen-touching and manual key entry perform identical operations.
- There are some screens where pen-touching is not allowed (embedded demonstration screens and sending of slide show screens, etc.).

# 2. Solver Function

- The EL-9650 is equipped with a solver function that allows a known variable to be input to solve an unknown variable. Hence it is possible to solve an equation using various variables.
- Only real numbers may be used in the solver function.

**<Example>**

In the equation Y = A + B, Y and B are known variables with values 2 and 5, respectively. The value of A will be calculated.

1. Delete the screen.
   Press [CL].
2. The display on the right will flash momentarily when pressing [2ndF] [SOLVER] to inform that it is in the solver mode.

```
SOLVER
```

3. Enter the equation:
   Press [ALPHA] [Y] [ALPHA] [=] [ALPHA] [A] [+] [ALPHA] [B] [ENTER].

```
Solver:Equation
 Y=0
 A=0
 B=0
```

4. Input the known variables:
   Input 2 for Y….2 [ENTER]
   Skip A since it is the unknown variable… [ENTER]
   Input 5 for B….5 [ENTER]
   Move the cursor to the location of the unknown variable A… [▲]

```
Equation solver
 A=-3
```

5. Execute the solver function.
   Press [2ndF] [EXE].
   It is simple to use the solver function by inputting known variables when there is only one unknown variable. See CHAPTER 9 on page 211 for details.

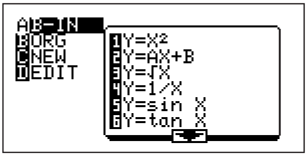
* After the solution has been found, press [CL] to return to the variable input screen. On this screen, you may change the numeric values in the variables and select another unknown variable to find the solution again.

# 3. SLIDE SHOW Function

The EL-9650 is equipped with commonly used formulas and graph screens to help understand the relationship between functions and graphs.

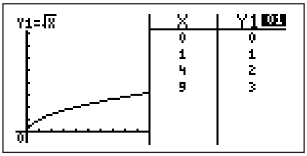
## (1) Viewing the installed demonstration screen

- Let's view the installed equation "Y= $\sqrt{X}$".



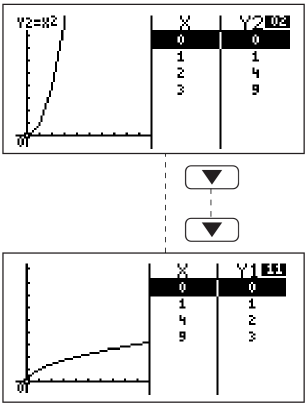

1. Press [SLIDE SHOW].
2. Press [A] [▶] [▼] [▼] [ENTER].

The screen will split as shown on the right. The left side displays the graph and its equation (depending on the screen, the equation may not appear) and the right side displays the list ($\boxed{01}$ on the upper right indicates the first demonstration screen of equation "Y = $\sqrt{X}$").



## (2) Advancing the demonstration screen by one page

1. Press [▼].
2. Next, the graph for "Y=$X^2$" appears. The screen number will change to $\boxed{02}$.
   Use the [▼] key to advance a page and [▲] to view the previous page.



The "Y = $\sqrt{X}$" screen is shown on the right, which is the last demonstration screen. Pages will not advance when pressing [▼] (11 screen data is available for "Y = $\sqrt{X}$").

* The number of demonstration screens for each equation differs.

* The installed data are only for viewing and cannot be corrected and changed. Touch-pen operations are also not used in this function. Only [▼] and [▲] are valid inputs.

For details on the slide show function, see CHAPTER 10 on page 221.

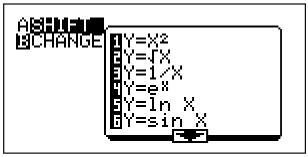
# 4. SHIFT/CHANGE Function

As with the slide show function, the EL-9650 is installed with a shift function. The shift function allows the installed equations and graph data to be displayed in order to view changes in graphs and formulas when shifting. It has a change function to see how graphs and formulas change after graphs are shifted.

## (1) SHIFT function

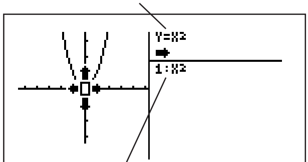
Shifting is observed using “Y=X²”.

1. Press [2ndF] [SHIFT/CHANGE].



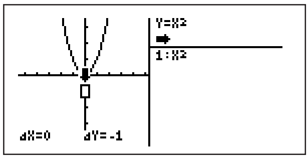

2. Press [A] [▶] [ENTER].
   The “Y=X²” graph will appear on the left side of the screen.
   The equation for the currently displayed graph will be displayed on the upper half of the right side of the screen. The bottom half of the same side displays the registered equation.
   The cursor “ ” will be displayed on the graph. This indicates the directions in which the graph can be moved, and that it is in standby mode.

Currently displayed graph

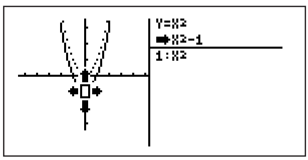



Registered equation

3. Press [▼] to shift the graph down.
   The cursor “ ” will be displayed, indicating that the graph will be shifted downwards.

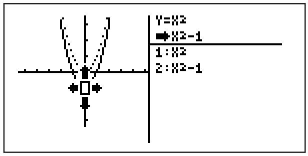



4. Press [ENTER] to confirm.
   The equation on the right will be changed with shifting executed.
   “Y=X²→X²–1”
   The solid lines indicate the graph “Y=X²–1”.



The dotted lines (....) on the screen indicates the graph “Y=X²”. (Previous graph).

* Graphs of registered equations are indicated using dotted lines (the first formula is automatically registered at the point when selecting “Y=X²”).

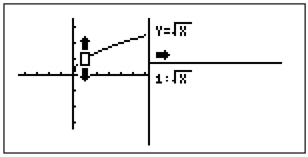



5. Press ENTER to register “Y=X²–1”. The screen as shown on the right will be displayed.
   To continue shifting, use ▼ ▲ ▶ ◀ as described earlier.
   “ΔX=0 ΔY=-1” displayed on the bottom of the graph indicates the amount the previous graph was shifted in the direction of the X axis and Y axis.
   For details, see CHAPTER 11 on page 229.

## (2) CHANGE function

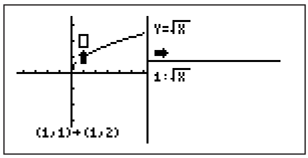
In the shift function, it is possible to view the relationship of graphs and equations using parallel shifting. In the change function, it is possible to view the relationship of equations and graphs by changing the graph format.

Let’s view the change using graph “Y= $\sqrt{X}$”.

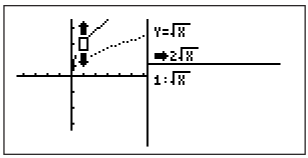



1. Press 2ndF SHIFT/CHANGE.
   Press B ▶ ▼ ENTER.
   Select graph “Y= $\sqrt{X}$”.

   The screen configuration is the same as for the shift function; however, since the graph formats are changed, the cursor becomes as shown on the right.
2. Press ▲ (the “Y= $\sqrt{X}$” graph moves upward).
   The changes in coordinates are displayed on the bottom left of the screen (in the diagram, (X=1, Y=1) is changed to (X=1, Y=2).




3. Press ENTER to confirm the change, and the previous graph will be displayed using dotted lines as with the shift function.
   The registering of equations and graphs is the same as in the shift function.




* It is possible to specify the shift amount and the change amount in the SHIFT/CHANGE function using the touch-pen.

For details, see CHAPTER 11 on page 236.

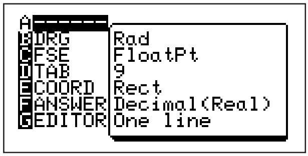
# CHAPTER 3
# MANUAL CALCULATIONS

Calculations using common math functions (addition, subtraction, multiplication and division)

Follow the steps described below before performing a calculation.
Press  to set to the normal function calculation mode. Press CL to clear the display.

**Checking the SET UP menu:**

Press 2ndF SET UP, change the EDITOR to One Line (as shown to the right).
If any of the settings are different, make necessary changes, since different settings may produce a different calculation result.




## 1. Arithmetic Calculations

| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | 49.6–75.2+32 = | 49.6 − 75.2 + 32 ENTER | 6.4 |
| 2 | 26+39÷0.5 = | 26 + 39 ÷ .5 ENTER | 104 |
| 3 | (26+39)÷0.5 = | ( 26 + 39 ) ÷ .5 ENTER | 130 |
| 4 | $\frac{75-6}{26-3}$ = | ( 75 − 6 ) ÷ ( 26 − 3 ) ENTER | 3 |
| 5 | -5×26 = | (−) 5 × 26 ENTER | -130 |
| 6 | $(4\times10^{3})\div(5\times10^{-2})$ = | 4 2nd F Exp 3 ÷ 5 2nd F Exp (−) 2 ENTER | 80000 |
| 7 | 5×(((36+18)×3)–64÷8) = | 5 ( ( ( 36 + 18 ) × 3 ) − 64 ÷ 8 ) ENTER | 770 |

- An entered expression is displayed on the left side of the screen. The answer of the entered expression is indicated on the right side of the screen.
- To enter “0.5”, it is accepted to enter “.5” by omitting “0”.

- If an answer is smaller than 1 (0.XXX...), the zero (0) indication in the first digit left of the decimal point is omitted on the display.
- All calculations inside parentheses ( ) are completed first.
  In example 3 above, if the parentheses were omitted, the calculation result would be the same as that of example 2.
- A negative number is entered by pressing (–) (not −) before the number, as shown in example 5.
  If − is mistakenly used in place of (–), an error will be generated. (Example: For the expression “5 × (-3)”, the use of − for the “-” sign of “-3” generates an error. Use (–).)
- The EXP key (secondary function of ,) is used to input exponents.
- In example 7, the input of × before ( may be omitted.
- A maximum of 32 parentheses (including those of other calculation instructions) can be used. However, the numeric values stored in an expression must not exceed 14.

# 2. Function Calculations

- Press [MATH KEY] to set to the common function calculation mode. Press [CL] to clear display.
- Check to make sure that the SET UP settings are as shown on CHAPTER 1 "10.SET UP Menu" on page 20.
- There are two groups of functions. The functions of one group are directly accessible from keys (such as log, sin, cos, etc.). The functions of the other group are selected from menu screens (such as $2^x$, sinh and $\int$ in the MATH, CALC menu.)

- Functions that are directly accessible from keys:
  Trigonometric functions (sin, cos, tan)
  Inverse trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$)
  Square ($x^2$), Reciprocal ($x^{-1}$), Common logarithms (log), Natural logarithms (In), Exponents ($10^x$, $e^x$), Pi ($\pi$), Fractions (a/b), Powers ($a^b$), Square roots ($\sqrt{\ }$), Xth roots ($\sqrt[a]{\ }$)
- Expressions with inverse trigonometric functions evaluate in the following ranges.

| $\theta = \sin^{-1} X$, $\theta = \tan^{-1} X$ | $\theta = \cos^{-1} X$ |
|---|---|
| Deg : $0 \leqq |\theta| \leqq 90$ | Deg : $0 \leqq \theta \leqq 180$ |
| Rad : $0 \leqq |\theta| \leqq \frac{\pi}{2}$ | Rad : $0 \leqq \theta \leqq \pi$ |
| Grad : $0 \leqq |\theta| \leqq 100$ | Grad : $0 \leqq \theta \leqq 200$ |

# (1) Input examples of functions accessible directly from keys

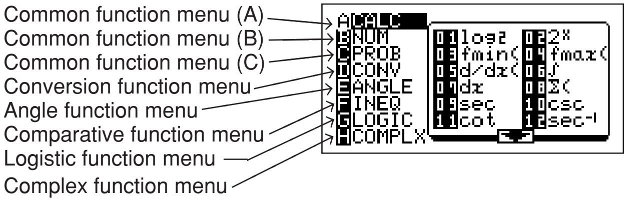
| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | sin 56 = ([B DRG] in SET UP must be changed to Deg) | sin 56 ENTER | .829037572 |
| 2 | cos ( $\frac{\pi}{4}$ ) = ([B DRG] in SET UP must be changed to Rad) | cos ( 2nd F π ÷ 4 ) ENTER | .707106781 |
| 3 | tan 150 = ([B DRG] in SET UP must be changed to Grad) | tan 150 ENTER | -1 |
| 4 | $\sin^{-1}$ 0.26 = ([B DRG] in SET UP must be changed to Deg) | 2nd F $\sin^{-1}$ 0.26 ENTER | 15.07006214 |
| 5 | $\cos^{-1}$-1 = ([B DRG] in SET UP must be changed to Rad) | 2nd F $\cos^{-1}$ (–) 1 ENTER | 3.141592654 |
| 6 | $\tan^{-1}$ 1 = ([B DRG] in SET UP must be changed to Grad) | 2nd F $\tan^{-1}$ 1 ENTER | 50 |
| 7 | $e^5$ = | 2nd F $e^x$ 5 ENTER | 148.4131591 |
| 8 | $10^{2.6}$ = | 2nd F $10^x$ 2.6 ENTER | 398.1071706 |
| 9 | In 25 = | In 25 ENTER | 3.218875825 |
| 10 | log 30 = | log 30 ENTER | 1.477121255 |
| 11 | $5^2 - 4^2$ = | 5 $x^2$ – 4 $x^2$ ENTER | 9 |
| 12 | $\frac{1}{8}$ = | 8 2nd F $x^{-1}$ ENTER | .125 |
| 13 | $\sqrt{36} + \sqrt{81}$ = | 2nd F √ 36 + 2nd F √ 81 ENTER | 15 |
| 14 | $3^5$ = | 3 $a^b$ 5 ENTER | 243 |
| 15 | $8^{-2}$ = | 8 $a^b$ (–) 2 ENTER | .015625 |
| 16 | $(15^3)^{\frac{1}{4}}$ = | 15 $a^b$ 3 $a^b$ 1 a/b 4 ENTER | 7.621991222*1 |
| 17 | $\sqrt[3]{121}$ = | 3 2nd F $\sqrt[a]{\ }$ 121 ENTER | 4.946087443 |
| 18 | $\frac{38}{7}$ = | 38 a/b 7 ENTER | 5.428571429 |

*1 In a complex calculation with multiple powers, an expression evaluates from the beginning. Therefore, the expression “2^3^2” is interpreted as “$(2^3)^2$”. To evaluate the expression “$2^{3^2}$”, enter “2^(3^2)”.

- When the angle mode is set to Rad, it is possible to input π based on the equation π = 180°(Deg).
  To enter, press 2ndF π. It is possible to input “π” in the Deg mode. In that case, calculations are based on “π = 3.14...” (degrees).

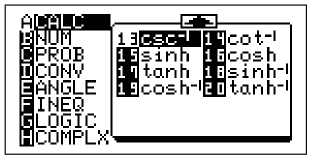
## (2) Functions selected from menus (MATH menu)

1. Press MATH.
2. Functions are grouped in the main menu, as shown below.
   In each group, functions are further divided into sub-menus.
   To select a function from a menu, move the cursor to the selected function, and press ENTER or touch the function name with the touch-pen. The display returns to the primary screen, and the selected function appears on the screen. When ENTER is pressed, the function is executed.




### Common function menu (A) [A CALC]:

- Press ► ALPHA ▼ to see the items after No. 13 (diagram on the right).




- There are a total of 20 functions in the CALC menu. The menu includes common logarithm to the base 2 ($log_2$), 2 raised to the Xth power ($2^x$), minimum and maximum function values (fmin, fmax), differential and integral functions (d/dx, ∫, dx), total sum (Σ(), trigonometric and inverse trigonometric functions (sec, csc, cot, $sec^{-1}$, $csc^{-1}$, $cot^{-1}$), and hyperbolic and inverse hyperbolic functions (sinh, cosh, tanh, $sinh^{-1}$, $cosh^{-1}$, $tanh^{-1}$).

- The following table shows an input example for each function. (The examples show only typical key operations. ▲, ▼, ◀ and ▶, but the touch-pen may also be used.)
  (See the list in APPENDIX "6. Explanation of EL-9650 menus" for the explanation of functions on page 284.)

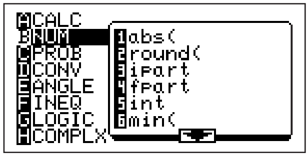
| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | Logarithm to the base 2: $\log_2 12$ | MATH A 0 1 12 ENTER | 3.584962501 |
| 2 | 2 to the Xth power: $2^5$ | MATH A 0 2 5 ENTER | 32 |
| 3 | To obtain the value of Y when the function Y has a minimum value (fmin). Finds the smallest value of "Y=X+2" (within the range of -3 to 3). | MATH A 0 3 X/θ/T/n + 2 , (–) 3 , 3 ) ENTER<br>The equation is entered in the sequence of fmin (equation, lower limit value, upper limit value and common difference). However the common difference may be omitted. | –3 |
| 4 | To obtain the value of Y when the function Y has a maximum value (fmax). Finds the largest value of "Y=2X–3" (within the range of -2 to 2). | MATH A 0 4 2 X/θ/T/n – 3 , (–) 2 , 2 ) ENTER<br>* The input procedure for equations is the same as for fmin. | 2 |
| 5 | Differential function d/dx $(x^2–5)$ (x = 2, when minute interval is 0.001) | MATH A 0 5 X/θ/T/n $x^2$ – 5 , 2 , 0.001 ) ENTER<br>(Input sequence: d/dx expression, numeric derivative, minute interval) | 4 |
| 6 | Integral function: "$\int_2^8 (x^3-0.5x^2+6)dx$" | MATH A 0 6 X/θ/T/n $a^b$ 3 – 0.5 X/θ/T/n $x^2$ + 6 , 2 , 8 MATH A 0 7 ENTER<br>* Input sequence: ∫ f(x), lower limit, upper limit [, tolerance] dx<br>• If tolerance is not specified, the default setting is 1E-5.<br>• At least 3,000 bytes of free memory are necessary to perform calculation. | 972 |
| 7 | Finds the total amount of "Y=X+2" (within the range of 1 to 5). | MATH A 0 8 X/θ/T/n + 2 , 1 , 5 ) ENTER<br>The equation is entered in the sequence of Σ (equation, starting point, ending point and increment). However, the increment may be omitted (the increment is set to 1 when omitted). | 25 |

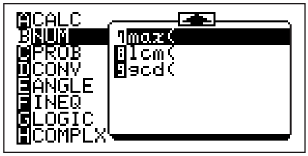
| No. | Example | Key operations | Answer |
|---|---|---|---|
| 8 | Trigonometric function: sec25 (Equation secx = ) (Angle mode:Deg) | MATH A 0 9 25 ENTER | 1.103377919 |
| 9 | Trigonometric function: csc60 (Equation cecx = ) (Angle mode:Deg) | MATH A 1 0 60 ENTER | 1.154700538 |
| 10 | Trigonometric function: cot 15 (Angle mode:Deg) | MATH A 1 1 15 ENTER | 3.732050808 |
| 11 | Inverse trigonometric function:$sec^{-1}$ 3 (Angle mode:Deg) | MATH A 1 2 3 ENTER | 70.52877937 |
| 12 | Inverse trigonometric function:$csc^{-1}$ 5.8 (Angle mode:Deg) | MATH A 1 3 5.8 ENTER | 9.928191842 |
| 13 | Inverse trigonometric function:$cot^{-1}$ 2.7 (Angle mode:Deg) | MATH A 1 4 2.7 ENTER | 20.32313683 |
| 14 | Hyperbolic function:sinh 3 | MATH A 1 5 3 ENTER | 10.01787493 |
| 15 | Hyperbolic function: cosh 4.5 | MATH A 1 6 4.5 ENTER | 45.01412015 |
| 16 | Hyperbolic function: tanh 2.8 | MATH A 1 7 2.8 ENTER | .99263152 |
| 17 | Inverse hyperbolic function:$sinh^{-1}$ 2.5 | MATH A 1 8 2.5 ENTER | 1.647231146 |
| 18 | Inverse hyperbolic function:$cosh^{-1}$ 3.1 | MATH A 1 9 3.1 ENTER | 1.797456568 |
| 19 | Inverse hyperbolic function:$tanh^{-1}$ 0.7 | MATH A 2 0 0.7 ENTER | .867300527 |

- In the CALC menu, it is possible to input expressions, lists and variables, in addition to numeric values.
  (To use variables, numeric values must be entered for the variables.)

## Common function menu (B) [B NUM]:

- Check the menu. Press [MATH] [B] to display the screen shown on the right.
- There are a total of nine options in the NUM menu. (See the list in APPENDIX “6. Explanation of EL-9650 menus” for the explanation of functions on page 287.)
- The menu includes functions that return absolute value [abs( ], rounded number [round( ], integer part [ipart], [int], fractional part [fpart], minimum and maximum values [min(], [max( ], least common multiple [lcm( ] and greatest common divisor [gcd( ].




**<Input examples>**

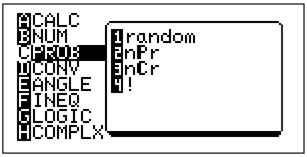
| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | Absolute value:\|log 0.75\|*1 (abs( ) | [MATH] [B] [1] [log] 0.75 [)] [ENTER] | .124938736 |
| 2 | Rounded number:3.5675*2 to second decimal places (round( ) | [MATH] [B] [2] 3.5675 [,] 2 [)] [ENTER] | 3.57 |
| 3 | To obtain the integer part of -5.726 (ipart) | [MATH] [B] [3] [(–)] 5.726 [ENTER] | -5 |
| 4 | To obtain the fractional part of 58÷8 (fpart) | [MATH] [B] [4] [(] 58 [÷] 8 [)] [ENTER] | .25 |
| 5 | To round -5.726 to the nearest integer (int) | [MATH] [B] [5] [(–)] 5.726 [ENTER] | -6 |
| 6 | Minimum value: To obtain the minimum value of 4.256 and 4.32*1 | [MATH] [B] [6] 4.256 [,] 4.32 [)] [ENTER] | 4.256 |
| 7 | Maximum value: To obtain the maximum value of 16.45 and 16.47*1 | [MATH] [B] [7] 16.45 [,] 16.47 [)] [ENTER] | 16.47 |
| 8 | Least common multiple: To obtain the least common multiple of 3 and 5*1 | [MATH] [B] [8] 3 [,] 5 [)] [ENTER] | 15 |
| 9 | Greatest common divisor: To obtain the greatest common divisor of 36 and 42*1 | [MATH] [B] [9] 36 [,] 42 [)] [ENTER] | 6 |

In the NUM menu, it is possible to input expressions, lists and variables, in addition to numeric values. However, numeric values must be entered for the variables.
For example, if list L1 contains {1, 2}, and list L2 contains {2, 3}, the following solution will result: lcm ($L_1$, $L_2$) $\rightarrow$ {2, 6}

*1 A closing parenthesis ) must be input at the end of the entry. If the parenthesis is not input, an error will be generated.

*2 Input of rounding function: round (numeric value, number of digits right of decimal point)
The indication of the number of digits to the right of the decimal point may be omitted.
(In this case, it complies to the FSE of SET UP and the TAB setting contents.)

## Common function menu (C) [C PROB]:




- Check the menu. Press [MATH] [C] to display the screen shown on the right.
- There are a total of four options in the PROB menu. (See the list in APPENDIX "6. Explanation of EL-9650 menus" for an explanation of functions on page 288.)
  The menu includes random number generation (random), permutation (nPr), combination (nCr) and factorial (!).

| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | Random number: Random number × 100 | [MATH] [C] [1] [×] 100 [ENTER] | 22.56631033 *1 |
| 2 | Permutation: $_8P_3$ *2 Total number of possible permutations for selecting 3 items from 8 items | 8 [MATH] [C] [2] 3 [ENTER] | 336 |
| 3 | Combination: $_9C_2$ *3 Total number of possible combinations for selecting 2 items from 9 items | 9 [MATH] [C] [3] 2 [ENTER] | 36 |
| 4 | Factorial:7! | 7 [MATH] [C] [4] [ENTER] | 5040 |

*1 The result produced by the random number function may not be the same as the answer given in the example due to the nature of this function. (Range of random number generation: 0 to 0.999999999)

*2 Permutation is expressed by "$nPr = \frac{n!}{(n-r)!}$".

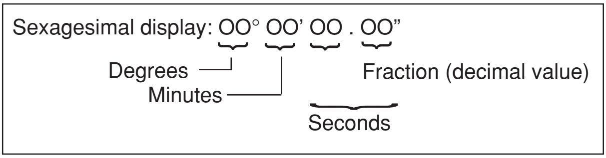
*3 Combination is expressed by "$nCr = \frac{n!}{r!(n-r)!}$".

## Decimal/sexagesimal degree conversion [D CONV]:

It is possible to convert numerical values between decimals (degrees) and sexagesimal (degrees, minutes, seconds).

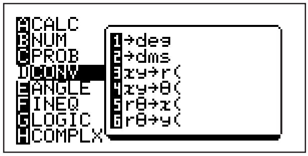
→deg: Converts sexagesimal (degrees, minutes, seconds) to decimals (degrees).

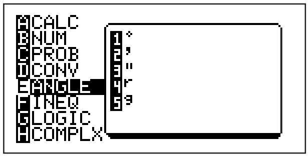
→dms: Converts a numerical values as decimals to sexagesimal (degrees, minutes, seconds)




(Seconds can be entered up to 2 decimal places as shown on the left.)

- To convert, specify [1 →deg] or [2 →dms] of the main menu’s [D CONV] of the MATH (MATH) menu.
- Pressing (MATH) (D) will display a screen shown on the right.
- To input degrees (°), minutes (’) and seconds (”) of a sexagesimal, use [1°](deg.), [2 ’](min.) and [3 ”](sec.) located in the main menu’s [E ANGLE] of the MATH menu.
- Pressing (MATH) (E) will display the screen shown on the right.




Let’s try converting angles using the two conversion menus.

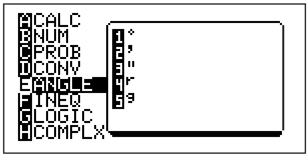
| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | (Sexagesimal →decimal conversion):<br>Convert 25°45'18" to decimals (degrees). | 25 MATH E 1 45 MATH 2 18 MATH 3 MATH D 1 ENTER<br>• You may omit selecting E for min. and sec., since equivalent screen of MATH will appear after opening the MATH [E ANGLE] for the first time to enter degrees, minutes and seconds. | 25.755 |
| 2 | (Decimal → sexagesimal conversion)<br>Convert 123.678 degrees to sexagesimal (deg., min., sec.) | 123.678 MATH D 2 ENTER | 123°40'40.8"<br>(123 deg. 40 min. 40 sec. 8) |
| 3 | Applied computation :<br>Time computation<br>Finds the total time for 3 hours 30 min. 45 sec. and 6 hours 45 min. 36 sec. | ( 3 MATH E 1 30 MATH 2 45 MATH 3 + 6 MATH 1 45 MATH 2 36 MATH 3 ) MATH D 2 ENTER<br>* Time can be entered in the same manner as degrees. | 10°16'21"<br>(10 hours 16 min. 21 sec.) |
| 4 | Convert the result of above example to decimals. | 2ndF ANS MATH D 1 ENTER | 10.2725 |

## Using angle conversion and others:

The calculator has 3 angle modes: Deg (degree), Rad (radian) and Grad (gradient). Correct calculation results cannot be achieved unless using the correct input method for each of the modes.

This calculator is equipped with a calculation function (MATH [E ANGLE]) that allows the use of these mode without changing settings.

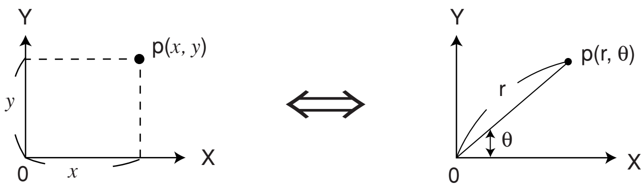
The screen shown on the right will appear when MATH E are pressed.




| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | Calculates sin 30°25'3" using the Rad mode (calculate using Deg) | sin ( 30 MATH E 1 25 MATH 2 3 MATH 3 ) MATH E 1 ENTER | .50629718 |
| 2 | Calculates cos π/6 using the Grad mode (calculate using Rad) | cos ( 2ndF π ÷ 6 ) MATH E 4 ENTER | .866025403 |
| 3 | Calculates tan 90 using the Deg mode (calculate using Grad) | tan 90 MATH E 5 ENTER | 6.313751515 |

## Rectangular/polar coordinate conversion [D CONV]:

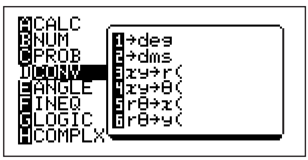
It is possible to convert rectangular coordinates to polar coordinates and vice versa.




Rectangular coordinates    Polar coordinates

Convert by pressing MATH then inputting numerical value after one of " $xy$→r(", "$xy$→θ(", "rθ→$x$(", or "rθ→$y$(" commands in [D CONV].

The menu screen shown to the right will appear when pressing MATH D are pressed.



## 1. Rectangular coordinates → Polar coordinates

$xy\to$r (:finds polar coordinate r from rectangular coordinates (x,y)

$xy\to\theta$ (:finds polar coordinate θ from rectangular coordinates (x,y)

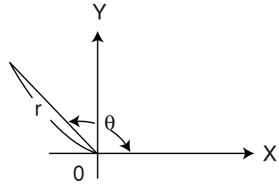
Conversion formulas: $r=\sqrt{x^2+y^2}$, $\theta=\tan^{-1}\frac{y}{x}$

The following scopes are used to find θ

Deg mode: $0 \leqq |\theta| \leqq 180$

Rad mode: $0 \leqq |\theta| \leqq \pi$

Grad mode: $0 \leqq |\theta| \leqq 200$




## 2. Polar coordinates → Rectangular coordinates

r$\theta\to x$ (:finds rectangular coordinate x from polar coordinates (r, θ)

r$\theta\to y$ (:finds rectangular coordinate y from polar coordinates (r, θ)

**<Coordinate conversion examples>**

| No. | Example | Key operations | Answer |
|---|---|---|---|
| 1 | Rectangular coordinate →polar coordinates: Convert coordinates (5,3) to polar coordinates (Angle mode:Deg) | First find r<br>MATH D 3 5 , 3 ) ENTER<br>Next find θ<br>MATH D 4 5 , 3 ) ENTER | 5.830951895<br><br><br>30.96375653 |
| 2 | Polar coordinates →rectangular coordinates: Convert coordinates (r=14, θ=π/3) to rectangular coordinates (Angle mode:Rad) | First find x<br>MATH D 5 14 , 2ndF π ÷ 3 ) ENTER<br>Next find y<br>MATH D 6 14 , 2ndF π ÷ 3 ) ENTER | 7<br><br><br>12.12435565 |
| 3 | Application example Find size and direction (phase) of vector i = 3+j9 (Angle mode:Deg) | First find the size<br>MATH D 3 3 , 9 ) ENTER<br>Next find the direction<br>MATH D 4 3 , 9 ) ENTER | 9.486832981<br><br><br>71.56505118 |

* For degree conversion, it is possible to input lists and variables. It is not restricted only to numerical values. To use variables, numeric values must be entered for the variables.

# 3. Binary, Octal, and Hexadecimal Calculations

In addition to the normally used numerical expression of decimals, binary, octal, and hexadecimal numerical expressions may be used.
This calculator allows conversions and calculations using the four rules of arithmetic and boolean operations of numerical values expressed in decimals, binary, octals, and hexadecimals

## (1) Binary, octal, decimal and hexadecimal numbers

Decimal (DEC): Most commonly used expression of numerical values using numbers from 0 to 9.

Binary (BIN): Expression of numerical values using only 0 and 1.

Octal (OCT): Expression of numerical values using numbers from 0 to 7.

Hexadecimal (HEX): Expression of numerical values using numbers from 0 to 9 and letters A, B, C, D, E, and F. A to F represent numbers 10 to 15 and letters A, B, C, D, E and F are used in this calculator. Use [sin] A [cos] B [tan] C [$x^2$] D [log] E [ln] F directly for entering the letters (the [ALPHA] function is not used).

## (2) Decimals shown as binary, octal, and hexadecimal numbers

| Decimal | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|---|
| Binary | 0 | 1 | 10 | 11 | 100 | 101 | 110 | 111 | 1000 |
| Octal | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 10 |
| Hexadecimal | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |

| Decimal | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|
| Binary | 1001 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 | 10000 | 10001 |
| Octal | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 20 | 21 |
| Hexadecimal | 9 | A | B | C | D | E | F | 10 | 11 |

## (3) Binary, octal, decimal and hexadecimal conversion

1. Press [+−×÷] to set to the standard function calculation mode.
2. Press [2ndF] [TOOL] [A] [ENTER] to display listing of numerical expressions.
   Conversions can be made while in this screen by inputting numerical values at the location of the flashing cursor.

Initial cursor position

```
HEX:
                 0
DEC:
                 0
OCT:
                 0
BIN:
                 0
```

**<Example>**

Convert 38 expressed in decimals to binary, octal, and hexadecimal numbers.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] [▼] 3 8 [ENTER].

```
HEX:
                26
DEC:
                38
OCT:
                46
BIN:
            100110
```

**<Example>**

Convert hexadecimal 2BC to binary, octal, and decimal numbers.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] 2 B C [ENTER].

```
HEX:
               2BC
DEC:
               700
OCT:
              1274
BIN:
        1010111100
```

**<Example>**

Convert 12.34 expressed in decimals to binary, octal, and hexadecimal numbers.

* Decimals are discarded for modes other than the DEC mode.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] [▼] 12.34 [ENTER].

```
HEX:
                 C
DEC:
             12.34
OCT:
                14
BIN:
              1100
```

- Numerical values in binary, octal, and hexadecimal modes can be expressed in the following number of digits:
  Binary: 16 digits
  Octal: 10 digits
  Hexadecimal: 10 digits
  An error is returned for calculations and conversions exceeding the above mentioned number of digits.
  An error is also returned for calculations and conversions with results exceeding the range.

- Decimals are not used for modes other than the DEC mode ([•] is inoperable). When converting numerical values with decimals to binary, octal, or hexadecimal, decimals are discarded and only the integers are converted.
- When numerical values of binary, octal, and hexadecimal modes are negative, the display is switched to complements of 2.

## (4) Binary, octal, and hexadecimal calculations (arithmetic calculations)

For binary (BIN), octal (OCT), and hexadecimal (HEX) modes, the four rules of arithmetic (+ – × ÷) can be used as in the decimal (DEC) mode. Calculations using parentheses and memory can be executed as well in the same manner as in the decimal (DEC) mode (however, function calculations and other calculations not mentioned above cannot be executed).

In decimal calculations, exponents may be entered using [Exp] and decimals may be used.

Calculation results for binary, octal, and hexadecimal modes are displayed with the same number of digits as with conversions. Calculation results are displayed with conversions to each number system.

### Binary calculation:

**<Example>**

Calculate “1011+110”.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] [▼] [▼] [▼] 1011 [+] 110 [ENTER].

```
HEX:
            11
DEC:
            17
OCT:
            21
BIN:
         10001
```

Calculate “(1010 - 111) × 10”.

Press [(] 1010 [−] 111 [)] [×] 10 [ENTER].

```
HEX:
             6
DEC:
             6
OCT:
             6
BIN:
           110
```

**Octal calculation:**

**<Example>**

Calculate “42 ÷ 6” in base 8.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] [▼] [▼] 42 [÷] 6 [ENTER].

```
HEX:
               5
DEC:
               5
OCT:
               5
BIN:
             101
```

Calculate “35 ÷ 6” in base 8.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] [▼] [▼] 35 [÷] 6 [ENTER].

```
HEX:
               4
DEC:
               4
OCT:
               4
BIN:
             100
```

## Hexadecimal calculation:

**<Example>**

Calculate “2FF–25”.

Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] 2FF [−] 25 [ENTER].

```
HEX:
             2DA
DEC:
             730
OCT:
            1332
BIN:
      1011011010
```

Calculate “(200 –FC) ÷ 3”.

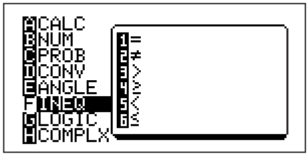
Press [+−×÷] [2ndF] [TOOL] [A] [ENTER] [(] 200 [−] FC [)] [÷] 3 [ENTER].

```
HEX:
              56
DEC:
              86
OCT:
             126
BIN:
         1010110
```

- There is no need to switch modes when continuing calculations after binary, octal, or hexadecimal conversions. Calculations can be continued as is.
- Press [Y=], [GRAPH], [TABLE], [WINDOW], [+−×÷], or [2ndF] [QUIT] to return to the previous screen from the current mode.
- Memory calculations cannot be used in this mode.

# 4. Test Functions

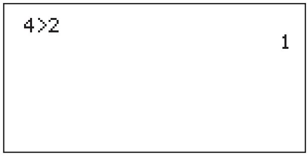
Using the inequality expressions, (=, ≠, >, ≥, <, ≤), value A and value B are compared, “1” is returned for true and “0” is returned for false. Real numbers, equations or lists can be used for value A and value B.
For matrices, only “=” and “≠” can be used and the dimensions of the matrices must be the same.
Inequality expressions are selected from the [MATH][F] menu.




**<Example>**

Compare 4 with 2 to see if 4 is bigger.

1. Press [⊞] 4 [MATH] [F] [3] 2.
2. Press [ENTER]. “1” is returned.




# 5. Boolean Operations

In binary, octal, decimal and hexadecimal modes, calculations with boolean expressions of and, or, not, xor and xnor may be used.
It is also possible to find complements (neg) to express negative values.

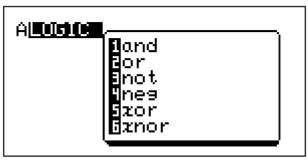
## (1) Table of true values for boolean operations

| A | B | A and B | A or B | A xor B | A xnor B |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 1 |

| A | not A |
|---|---|
| 0 | 1 |
| 1 | 0 |

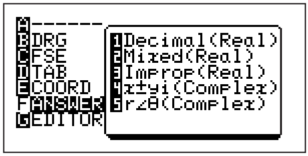
Press [MATH] to select a boolean operator (and, or, not, neg, xor, or xnor).

- For binary, octal, decimal, and hexadecimal modes after pressing [⊞] [2ndF] [TOOL] [A] [ENTER], results executed with boolean operations using only one number system can be converted and listed in the remaining number systems as well.

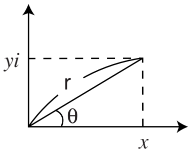


| No. | Example | Key operations | Display |
| --- | --- | --- | --- |
| 1 | Binary: using "and" for 1011 and 101 | [⊞] [2ndF] [TOOL] [A] [ENTER] [▼] [▼] [▼] 1011 [MATH] [1] 101 [ENTER] | HEX: 1<br>DEC: 1<br>OCT: 1<br>BIN: 1 |
| 2 | Hexadecimal: using "or" for 5A and E2 | [⊞] [2ndF] [TOOL] [A] [ENTER] 5A [MATH] [2] E2 [ENTER] | HEX: FA<br>DEC: 250<br>OCT: 372<br>BIN: 11111010 |
| 3 | Binary: using "not" for 101110 | [⊞] [2ndF] [TOOL] [A] [ENTER] [▼] [▼] [▼] [MATH] [3] 101110 [ENTER] | HEX: FFFFFFFFD1<br>DEC: -47<br>OCT: 7777777721<br>BIN: 1111111111010001 |
| 4 | Hexadecimal: using "neg" for complement of 1 | [⊞] [2ndF] [TOOL] [A] [ENTER] [MATH] [4] 1 [ENTER] | HEX: FFFFFFFFFF<br>DEC: -1<br>OCT: 7777777777<br>BIN: 1111111111111111 |
| 5 | Octal: using "xor" for 36 and 52 | [⊞] [2ndF] [TOOL] [A] [ENTER] [▼] [▼] 36 [MATH] [5] 52 [ENTER] | HEX: 34<br>DEC: 52<br>OCT: 64<br>BIN: 110100 |
| 6 | Hexadecimal: using "xnor" for A5 and 2F | [⊞] [2ndF] [TOOL] [A] [ENTER] A5 [MATH] [6] 2F [ENTER] | HEX: FFFFFFFF75<br>DEC: -139<br>OCT: 7777777565<br>BIN: 1111111101110101 |
| 7 | Hexadecimal: using "or" and "and" for 70, 3E, and A2 | [⊞] [2ndF] [TOOL] [A] [ENTER] [(] 70 [MATH] [2] 3E [)] [MATH] [1] A2 [ENTER] | HEX: 22<br>DEC: 34<br>OCT: 42<br>BIN: 100010 |
| 8 | Hexadecimal: using "and" for 3D and 35 then adding 12 | [⊞] [2ndF] [TOOL] [A] [ENTER] [(] 3D [MATH] [1] 35 [)] [+] 12 [ENTER] | HEX: 47<br>DEC: 71<br>OCT: 107<br>BIN: 1000111 |

# 6. Calculations Using Complex Numbers




- To execute calculations using complex numbers, select sub-menu item [4 $x \pm yi$] or [5 r∠ θ] within [F ANSWER] in the SET UP menu screen.
  [2ndF] [SET UP] [F] [4] or [5]
- The initial screen for the complex number calculation mode is the same as for the real number mode.
- Complex numbers can be noted using either [4 $x \pm yi$]: (rectangular coordinates) or [5 r∠ θ](polar coordinates).



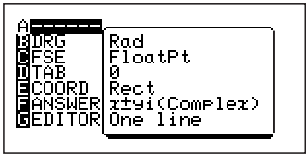

## (1) Usable function keys (main unit keys) in the complex number mode

The following functions can be used for complex numbers. There are no limits for calculations using real numbers:

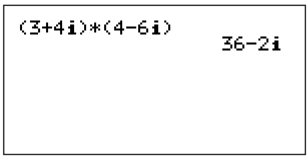
$x^2$, $x^{-1}$, log, ln, $10^x$, $e^x$, $a^b$, $\sqrt{\ }$, $\sqrt[a]{\ }$

**<Example>**

Calculate “(3+4i) × (4–6i)”.




1. Press [2ndF] [SET UP] and check to see that the second line from bottom of the right in the set contents screen displays “x±yi”.
   To change the setting to “x±yi”, press [2ndF] [SET UP] [F] [4].
2. Press [CL] [(] 3 [+] 4 [2ndF] [i] [)] [×] [(] 4 [−] 6 [2ndF] [i] [)] [ENTER].




* It is possible to input complex numbers (i) in the real number mode (real). However, an error is returned when pressing [ENTER].

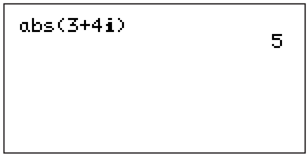
## (2) Usable functions (menus) for complex numbers

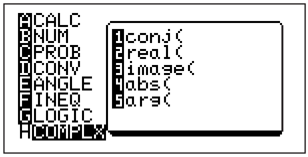
Some of the functions within menu screens can be used for complex numbers, including abs, ipart, fpart, etc.
(For details, see table on page 282, APPENDIX “6. Explanation of EL-9650 menus”, describing usable functions in the complex number mode according to menus of this calculator.)

**<Example>**

Find the absolute value of “3+4i”.

Press MATH B 1 3 + 4 2ndF *i* ) ENTER.




In the MATH menu, there is a function sub-menu exclusively for complex numbers.

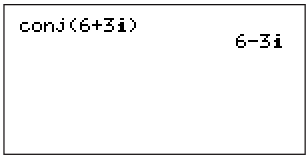
Press MATH H.

**[conj(]:** finds the complex conjugate

**<Example>**

Find the complex conjugate of “6+3i”.

Press MATH H 1 6 + 3 2ndF *i* ) ENTER.



Calculations can also be performed.

**<Example>**

Find the complex conjugate of “(5+2i) × (3–4i)”.

Press ⊞ MATH H 1 ( 5 + 2 2ndF *i* ) × ( 3 − 4 2ndF *i* ) ) ENTER.

```
conj((5+2i)*(3-4i))
                23+14i
```

**[real(]:** finds real part of a complex number in polar form

**<Example>**

Find real part of polar coordinates “15∠ 30” (angle mode:Deg)

Press ⊞ MATH H 2 15 2ndF ∠ 30 ) ENTER.

```
real(15∠30)
           12.99038106
```

* Angles can be entered using Deg, Rad, and Grad modes.

**[image(]:** finds imaginary part of a complex number in polar form.

**<Example>**

Find the imaginary part of the complex number “$(15+2i)^2$”.

Press ⊞ MATH H 3 ( 15 + 2 2ndF *i* ) $x^2$ ) ENTER

```
image((15+2i)²)
                    60
```

**[abs(]:** finds the absolute value (same as MATH, [B NUM], and [1 abs(]).

**[arg(]:** finds angle “$x+yi$” when converting θ (rectangular coordinates) to polar coordinates)

Formula: $\theta=\tan^{-1}(y/x)$

**<Example>**

Find angle (argument) of “7+5i” (angles mode:Deg).

Press ⊞ MATH H 5 7 + 5 2ndF *i* ) ENTER.

```
arg(7+5i)
           35.53767779
```

# 7. Convenient and Useful Functions

## (1) Last entry function

- The EL-9650 is equipped with a temporary memory area that stores expressions entered for calculation.
- Expressions that have been executed are stored in an executing order until the temporary memory becomes full. When the capacity of the temporary memory is exceeded, stored expressions are deleted in order from the oldest. Therefore, previously entered expressions can be recalled only when they are still stored in the temporary memory.
- A maximum of 160 bytes can be stored in the temporary memory.
  The capacity may vary slightly when there are division codes between expressions.
- Please note that when switching (changing) from the Equation edit mode to One-line edit mode in the SET UP menu, all numerical equations and graph equations automatically stored to the temporary memory will be cleared and cannot be recalled.

### Operating instructions:

- To recall the expression evaluated immediately before, press 2ndF ENTRY. The previous expression appears on the display.
- To recall the expression evaluated before the previous one, press 2ndF ENTRY. Repeat this step to continue recalling expressions in an order from the newest.
- If a recalled expression is evaluated again, it will be added to the temporary memory as the newest data.
- Data in the temporary memory can be deleted by changing the editor type and resetting.

**<Example>**

1. Enter following expressions:

   $10 + 5 =$

   $\sqrt{121} =$

   $6 \times 3 + 2 =$

   $15 \div 3 =$

   To recall previous expressions in sequence after evaluating the above expression.

```
                 15
√121
                 11
6*3+2
                 20
15/3
                  5
```

2. The expression "15 ÷ 3" evaluated before the previous one is displayed at the bottom of the display.
   Press [2ndF] [ENTRY].

```
                    15
√121
                    11
6*3+2
                    20
15/3
                     5
15/3_
```

3. The expression "6 × 3 + 2" evaluated before the expression "15 ÷ 3" is recalled and displayed at the location of "15 ÷ 3".
   Press [2ndF] [ENTRY].

```
                    15
√121
                    11
6*3+2
                    20
15/3
                     5
6*3+2_
```

When expressions continue to be recalled without editing or evaluating, they appear at the bottom of the display.

## (2) Continuing calculations using last answer

- The answer resulting from evaluating an expression (by pressing [ENTER]) can be used in the next calculation.
  To use the previous calculation result, press [2ndF] [ANS] at the location where the result is to be inserted.
- The "Ans" indication on the display represents the result of the previous calculation.
  The previous answer may be used two or more times in a single expression.
  Note that the numeric value represented by "Ans" changes when a new expression is evaluated.
  (If an error is generated during a calculation, the previous answer remains as the value of "Ans".)

**<Example 1>**

To evaluate "5 + 6 × 20", and obtain the square root of that answer.

1. Press 5 [+] 6 [×] 20 [ENTER]
   to obtain the answer of "5 + 6 × 20".
2. Press [2ndF] [√] [2ndF] [ANS] [ENTER]
   to obtain the square root of the above answer.

```
5+6*20
                   125
√Ans
           11.18033989
```

**<Example 2>**

Apply the result of "3+2" to the next equation
"10 × (3+2) + $2^{(3+2)}$ =".

Key operation:

1. Press 3 [+] 2 [ENTER].
2. Press 10 [×] [2ndF] [ANS] [+] 2 [$a^b$] [2ndF] [ANS] [ENTER].

```
3+2
                     5
10*Ans+2^Ans
                    82
```

**<Example 3>**

Pressing ENTER after executing a calculation replaces the contents in Ans with the latest results and continues calculation.

After executing "3+1", proceed with "2 × Ans".

1. Press 3 + 1 ENTER.
   "Ans=4" is stored in memory.
2. Press 2 × 2ndF ANS ENTER.
   4 of "Ans" is replaced by 8.
3. Press ENTER.
   "2 × 8" is executed and Ans is replaced with 16.
4. Press ENTER.
   "2 × 16" is executed and "Ans" is replaced with 32.

```
3+1
                4
2*Ans
                8
               16
               32
```

## (3) Memory calculations

It is possible to store numerical values to independent memories A to Z and θ. Here, memory calculations using the independent memory are explained.

### Using the independent memory (A to Z and θ):

It is possible to store different numerical values in memory spaces A to Z and θ (total of 27). You can store numerical values or calculation results in the memory and use in equations.

* It is also possible to store the calculation results in the memory using "Ans".
  To do so, press 2ndF ANS STO ALPHA A ( or B to Z , θ ) ENTER.

* Variables X, Y, R, and θ will change when executing graph, etc.

**<Example 1>**

Store calculation result of "(12+6) × 2" in memory A and calculation result of "5 × sin60" in memory B. (Angle mode:Deg)

1. Press ( 12 + 6 ) × 2 STO ALPHA A ENTER.
2. Press 5 sin 60 STO ALPHA B ENTER.

(Specify memory space using A to Z and θ after pressing STO. It is necessary to use ALPHA to input alphabets.)

```
(12+6)*2⇒A
               36
5sin 60⇒B
      4.330127019
```

* To clear memory contents, store "0" to the memory space.

**<Example 2>**

Clear contents of memory C.

Press 0 [STO] [ALPHA] C [ENTER].

```
0⇒C
                    0
```

To recall memory, [RCL] or [ALPHA] may be used.

**<Example 3>**

Recall memory A and B with stored data from example 1 (A = 36 and B = 4.330127019) using different approaches.

- When using [RCL]: [2ndF] [RCL] [ALPHA] A [ENTER]

```
36_
```

- When using [ALPHA]: [ALPHA] B [ENTER]

```
B
          4.330127019
```

When using [2ndF] [RCL] to recall memory, "RCL_" will appear on the bottom left of the screen. Input the memory name here.

Calculating using memory (Although [ALPHA] is used in the example below, [RCL] may also be used as in the previous example.)

**<Example 4>**

Use A and B entered in example 1 to execute "A × B/(A + B)".

Press [ALPHA] A [ALPHA] B [÷] [(] [ALPHA] A [+] [ALPHA] B [)] [ENTER]

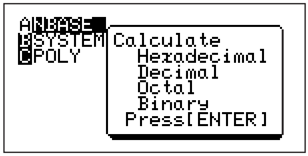
```
AB/(A+B)
          3.865214027
```

* "×" notations may be omitted for calculations involving multiplication of memories such as A×B or when numerical values come first such as 3×A and 5×B.

* All memory of A to Z and θ are maintained even when pressing [CL] or when shutting the power supply off.

## (4) TOOL menu

- The TOOL menu is equipped with functions to convert and execute binary, octal, decimal, and hexadecimal expressions as well solve simultaneous linear equations and polynomial equations.
- Press 2ndF TOOL to enter the TOOL menu (the display to the right will appear).




  [A NBASE] .... Menu to execute binary, octal, decimal and hexadecimal calculations.

  [B SYSTEM] . Menu to solve simultaneous linear equations.

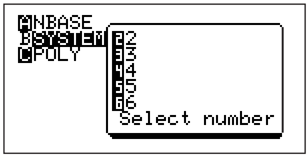
  [C POLY] ....... Menu to solve polynomial equations.

**1. [A NBASE]**

See the previous pages for details of this function. (See CHAPTER 3 “4. Boolean Operations” on page 67)

**2. [B SYSTEM]**

- It is possible to solve simultaneous linear equations with two to six unknown values using this function.
- Press 2ndF TOOL B to display the screen shown on the right.




- The sub-menu to select the number of unknown values for the linear equation will appear on the right side of the screen.
  [2 2] solves simultaneous linear equations with two unknown values and [3 3] solves simultaneous linear equations with three unknown values.

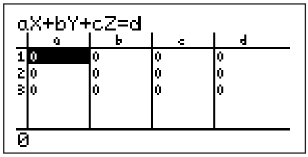
**<Example>**

Solve the system of equations.

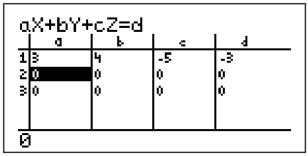
  3X + 4Y –5Z = –3: equation 1

  2X – 8Y + 3Z = 2: equation 2

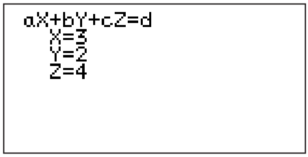
  4X + 2Y +Z = 20: equation 3




- Enter the mode to solve simultaneous linear equations with three unknown values by pressing 2ndF TOOL B 3.
  The input screen shown on the right will appear.
  Equation types are displayed on the top of the screen.
  The list of coefficients (a, b, c, d) allowed for input (the cursor pointer is located on the first line of a) is displayed below.
  Only 4 coefficients are displayed at a time. Use the ◄ ► to scroll the screen.
  Input values are displayed on the very bottom of the screen.



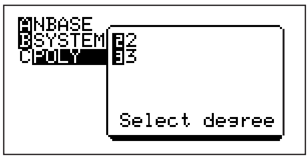

1. Input each coefficient of equation 1 by entering:
   3 ENTER 4 ENTER (—) 5 ENTER (—) 3 ENTER
2. Input each coefficient of equation 2 by entering:
   2 ENTER (—) 8 ENTER 3 ENTER 2 ENTER
3. Complete coefficient input by entering:
   4 ENTER 2 ENTER 1 ENTER 20 ENTER
4. Press 2ndF EXE to execute calculation. The results are displayed on-screen.
   Answer: X=3
   Y=2
   Z=4




- To solve simultaneous linear equations with two to six unknown values, first select using 2ndF TOOL B 2 (or 3 to 6), then enter coefficients using the procedure mentioned above.

**3. [C POLY]**

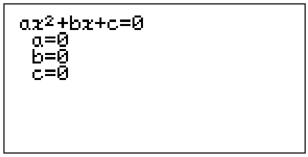
- It is possible to solve polynomial equations using this function.
- Press 2ndF TOOL C to enter the mode which solves polynomial equations. The screen shown on the right will appear.
  [2 2] solves quadratic equations.
  [3 3] solves cubic equations.



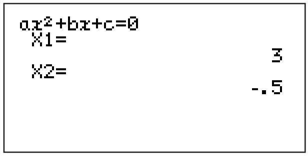
- This function is explained using an example.

**<Example>**

The quadratic equation “a$x^2$ + bx + c = 0” is solved using parameters “a=2”, “b=-5” and “c=-3”.




1. Press [2ndF] [TOOL] [C] [2].
   (Select quadratic equation)
   The screen shown on the right will appear asking for input of each parameter. Since the cursor pointer is positioned at “a”, enter starting with value a.
2. Complete parameter entry by pressing 2 [ENTER] [(—)] 5 [ENTER] [(—)] 3 [ENTER].
3. Press [2ndF] [EXE] to execute calculation as shown on the right.



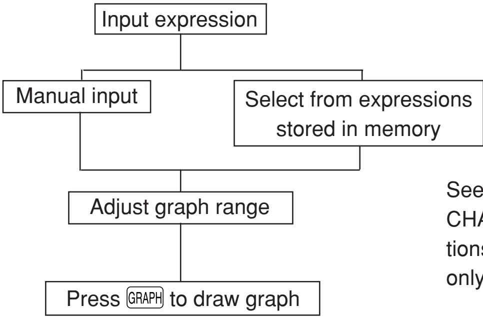

- To solve cubic equations, press [2ndF] [TOOL] [C] [3] then input each parameter following the example mentioned above (for cubic equations, four parameters of a to d are entered).
- “ ↓ ” symbol will appear on the bottom left of the screen if the solution cannot be shown on the screen at one time. Use [▼] to scroll the screen.

# CHAPTER 4
# GRAPHING FUNCTIONS

This chapter describes the method of displaying a graph by specifying functions and parameters.

## 1. Function Graphing Procedures

In the EL-9650, there are two input methods for displaying a graph.

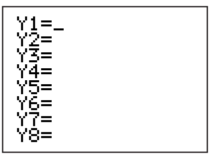



See the Rapid graph on page 124, CHAPTER 4 “15. Useful Functions” for details. (This mode is only for rectangular coordinates.)

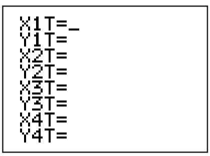
## 2. Graph Modes

- The EL-9650 has four graph modes (rectangular coordinate graph, parametric coordinate graph, polar coordinate graph, and sequence graph).
- To select a mode, use the SET UP settings. (Press 2ndF SET UP.)
  (See CHAPTER 1 “10. SET UP Menu” on page 20 for details.)
- The input method varies depending on the mode.

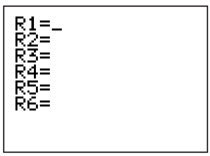
X-Y coordinates



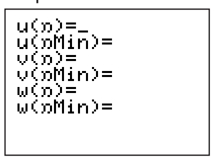

Parametric coordinates




Polar coordinates




Sequence coordinates



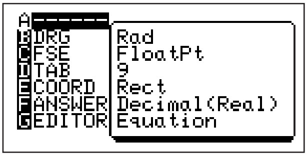
# 3. Rectangular Coordinate Graphing

- In the rectangular coordinate graph mode, ten functions can be stored in Y1 to Y9 and Y0 for graph drawing.
- The rectangular coordinate graph mode is the default setting of the EL-9650.

The following section describes the procedures to draw a graph of equations "$Y1=-(X+2)^2+5$" and "Y2=X–2", and then explains graphing functions.

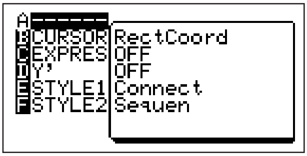
## (1) Setting the rectangular coordinate graph mode

Press 2ndF SET UP to display the screen shown on the right.
The graph mode is set by [E COORD].
Check to make sure that it is set to Rect.
If it is set differently, change the setting to Rect.




## (2) Checking the format (See page 97 for details.)

- Press (graph key) 2ndF FORMAT.
  The FORMAT menu is used to specify the graph style.
  Check to make sure that the settings are the same as the ones shown on the right. If any of the settings are different, the displayed screen may differ from the screen described below.
  The screen on the right shows the default settings of the EL-9650.



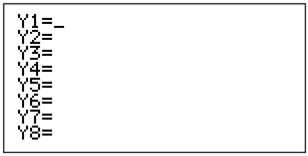

* In the sequence coordinate graph mode, the [G TYPE] indication appears at the lower right corner on the display.
When this happens, set [E COORD] of the SET UP menu to [1 Rect].

- The following briefly explains the items on the FORMAT menu.

| | | |
|---|---|---|
| A | ------ | : To display the list of the settings of the mode |
| B | CURSOR | : To set the graph coordinate system |
| C | EXPRES | : To set whether or not to display the graph equation on the screen |
| D | Y' | : To set whether or not to display the graph slope (dy/dx) on the screen |
| E | STYLE1 | : To specify line graph or dot graph |
| F | STYLE2 | : To set the graph drawing method |
| G | TYPE | : To set the axis for sequence coordinate graphing |

## (3) Entering a function (See page 98 for details.)

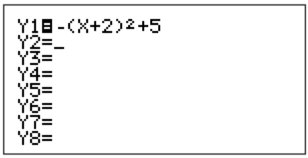
1. Press [⊞] [Y=].
   As shown on the right, the screen prompts for the inputs of Y1 to Y8. (The calculator can store up to 10 functions. To display Y9 and Y0, scroll the screen to display the next page. To input functions in Y9 and Y0, use [▼] to move the cursor to the input position.)



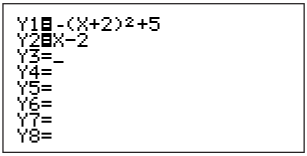

2. Enter "–(x + 2)$^2$ + 5" in "Y1".
3. When [Y=] is pressed to display the above screen, the cursor is located at [Y1]. This indicates that the calculator is ready to accept the input for Y1.
4. On this screen, operate the following keys.
   Press [(–)] [(] [X/θ/T/n] [+] 2 [)] [$x^2$] [+] 5 [ENTER].
   When any key is pressed, the "=" sign next to "Y1" is highlighted and changes to "▨". The appearance of the sign indicates whether the function will be made into a graph or not when [GRAPH] is pressed.
   ▨ : Graph to be drawn.
   = : Graph not to be drawn.

* In the rectangular coordinate graph mode, [X/θ/T/n] enters "X". This eliminates the need to press [ALPHA] X to input "X".

5. When [ENTER] is pressed, the cursor automatically moves to [Y2]. The screen will look like the one shown on the right.

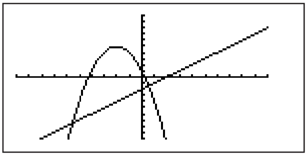


6. Enter “X–2”.
   Key operations: X/θ/T/n ( – ) 2 ENTER
7. The cursor moves to [Y3]. This completes the input of the functions.




## (4) Displaying graphs

- To display a graph, press GRAPH.
- A graph will be created according to the Y1 and Y2 functions, as shown on the right.
- To cancel the displaying of a graph, press ( ON ).



## (5) Zooming in on graphs (See page 100 for details.)

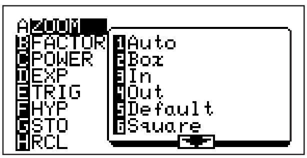
- The graph that appears when GRAPH is pressed in the above step is displayed in the default setting range, called window.
- The initial values of the rectangular coordinate graph mode are shown below.

| | | |
|---|---|---|
| Xmin | = | -10 |
| Xmax | = | 10 |
| Xscl | = | 1 |
| Ymin | = | -10 |
| Ymax | = | 10 |
| Yscl | = | 1 |

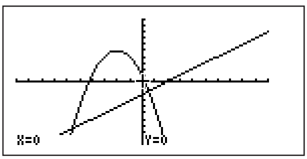
* Window means settings that specify the display area. For details, see CHAPTER 4, “11. Setting a Window” on page 104.

- In the following steps, the intersection and maximum value are obtained. For easy viewing, zoom in on the graph.
- To zoom in, press ZOOM. There are several methods for zooming. Use the sub-menu of the ZOOM menu to make a selection.

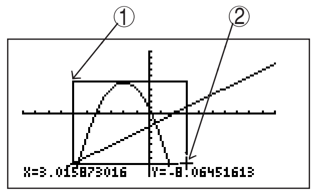
1. Press ZOOM.
2. Press ( 2 ) to select [2 Box].
   (The BOX function allows the selection of a section to be enlarged by displaying a rectangular box.)




   The display returns to the previous graph screen, and the cursor starts flashing near the center of the display.

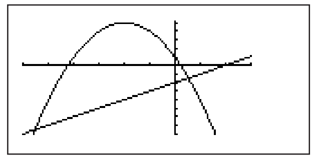


**Procedures:**




The following steps enlarge the section of the graph marked by ☐ in the diagram shown on the right.

1. Move the cursor to corner ①, and press [ENTER]. ( [▲] [▲]... [◀] [◀]... [ENTER])
2. Move the cursor to corner ②. ([▼] [▼]... [▶] [▶]...)
   A rectangular box appears on the display to show the section selected for zooming.
3. Press [ENTER]. The section of the graph selected by the rectangular box is drawn to fill the entire graph display area.



* The touch-pen can also be used to select a section to zoom.

* When the touch-pen is used, touch corner ① twice with the pen, then touch corner ② twice.

* When the zoom function is used, the graph range changes from the initial value according to the zooming ratio.
  The graph range stays in that setting unless the range setting is changed or returned to the default setting.

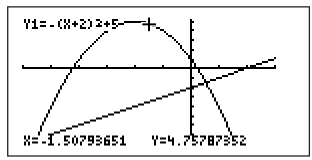
## (6) Displaying equations

Before using the trace function, follow the steps below to display the equation of the graph shown on the screen.

The [C EXPRES] menu of the FORMAT menu is used to display an equation on the screen.

Press [2ndF] [FORMAT] [C] [1] [CL] [TRACE].

The equation "Y1=–(x+2)²+5" will be displayed at the upper left corner of the display.

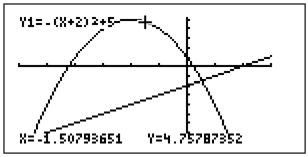


Equation of the displayed graph

* Only one equation can be displayed. Of the entered functions, the equation with the smallest graph number is displayed.
  The function equation can be displayed on the TRACE screen.

## (7) Trace function for moving the cursor pointer on the graph

The trace function allows the cursor pointer to be moved on the graph and displays the coordinates.

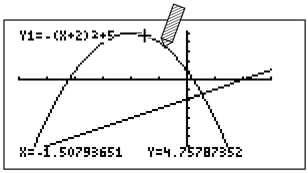



- Set to the TRACE mode.
  Press [TRACE].
  As shown on the right, a flashing cursor pointer appears on the equation curve. The X and Y coordinates of the cursor pointer position are displayed at the bottom of the screen.
- Moving the cursor pointer
  There are two ways to move the cursor pointer on a graph.

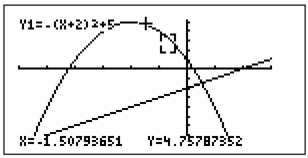
① Using [◄] [►]:

- When [◄] is pressed, the cursor pointer moves to the left on the equation curve.
- When [►] is pressed, the cursor pointer moves to the right on the equation curve.

② Using the touch-pen:




- With the touch-pen, touch the location on the display. The cursor pointer moves to the selected position.
  A “⌜ ⌟” mark appears on the screen. This mark indicates the selected position.
- If the position is acceptable, touch inside the “⌜ ⌟” mark. This enters the selected position, and moves the cursor to a point on the curve inside the “⌜ ⌟” mark. (The location to which the cursor moves is a calculation point on the graph within the “⌜ ⌟” mark, which is obtained by the calculator’s internal processing. If the graph slope is steep and there is no calculation point within the “⌜ ⌟” mark, the cursor moves to a calculation point nearest to the “⌜ ⌟ ” mark. Therefore, the cursor pointer may be positioned outside the “⌜ ⌟” mark in some cases.)




* If the displayed “⌜ ⌟” mark is not located at the selected position, touching another position with the touch-pen moves the “⌜ ⌟” mark to the newly selected position.

* If the “[ ]” mark is not positioned over a graph, touching the same position with the touch-pen does not move the cursor.

After leaving and returning to the TRACE screen, the cursor will be located at the same position as it was in the previous TRACE screen (not at the initial position).

### When the cursor pointer is moved beyond the screen border:

When the cursor pointer is moved beyond the display border by using ◀ or ▶

1: If the cursor pointer is moved beyond the left or right edge of the display, the calculator scroll the screen left or right automatically to show the cursor pointer.

2: If the cursor pointer is moved beyond the top or bottom edge of the display, the cursor pointer is no longer on the screen, and only the X and Y coordinates are shown. (The coordinate values change in accordance with the cursor position.)

- If the cursor pointer is located outside the screen, press TRACE again when the trace screen is displayed. The screen will change the display area so that the cursor pointer appears near the center of the display.

### Changing the graph (equation) to trace:

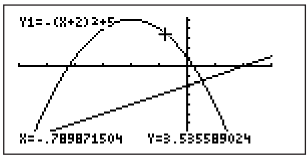
There are two ways to move the cursor pointer to another graph.

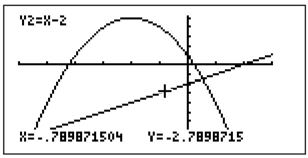
① Using ▲ ▼:

When ▼ is pressed, functions valid for graphing are selected in an order from the newest entry to the oldest. (The order of the selection is opposite when ▲ is pressed.)

② Using the touch-pen:

To select another equation curve, touch the graph with the touch-pen, as shown on the right. The “[ ]” mark appears when the graph is touched once (the screen is similar to that for moving the cursor). When the same position is touched again with the pen, the cursor pointer moves.




* Note that if a graph or calculation point is not located within the “[ ]” mark, the above operation is invalid.

* If two or more graphs are located within the “[ ]” mark, the one with the smallest equation number will be selected.

When the graph with the cursor pointer indication is changed in either of the previous two methods, the equation displayed at the upper left corner of the display also changes to the one for the newly selected graph.
(The previous example shows the screen after the cursor pointer is moved from the equation "Y1 = –(x+2)$^2$+5" to the equation "Y2 = x–2".)

* Since the X and Y coordinates vary depending on the location of the cursor pointer, the displayed values may differ from those in the examples.)

## Free-moving cursor:

The above explanation showed the methods of moving the cursor on a graph. The cursor can also be moved freely on the screen.

There are two ways to set the cursor to the free-moving mode.

In either method, the screen must be in the graph display mode (not in the TRACE mode).

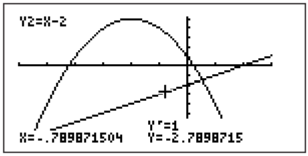
① Press any of ◄, ►, ▼, and ▲ to display the cursor pointer (flashing) on the display. Press ◄, ►, ▼, or ▲ to move the cursor freely on the display.

② Select a point on the display using the touch-pen.
When the screen is touched, the "⌜ ⌝" mark appears on the display. Touch the same location again to display the cursor pointer. After the cursor pointer appears on the display, ◄, ►, ▼, and ▲ can be used to move the cursor pointer dot by dot. The touch-pen can be used to designate a new location.

## (8) Displaying numerical derivative Y' of graphs

A numerical derivative of a graph is expressed by dy/dx. This calculator features a function that displays a numerical derivative Y' (dy/dx).

- To display Y', set [D Y'] of FORMAT menu to [1 ON].
- Key operations: [2ndF] [FORMAT] [D] [1] [CL]
  When the above keys are pressed, Y' appears above Y at the lower right corner of the display.



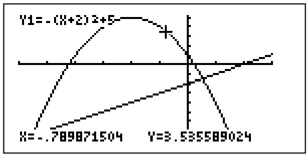

- When the cursor pointer is moved by the trace function, the Y' coordinates also change, in the same way as for X and Y.
  If the Y' indication is not needed, it can be turned off using the previously mentioned Y' menu.

## (9) CALC functions (See page 117 for details.)

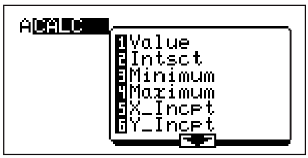
The CALC functions perform calculations.
To use a function, press [2ndF] [CALC].

**<Example>**

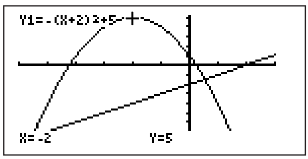
To obtain the maximum value of "Y1 = –(x+2)²+5".
Display the cursor pointer at Y1 to select graph Y1. (Press [TRACE].)




- Press [2ndF] [CALC] to display the CALC menu.
- [4 Maximum] provides maximum values. To select, press [4]. The cursor moves to the maximum value point of the graph "Y1 = –(x+2)²+5", as shown below.
  The coordinates are displayed at the bottom of the display.




* When calculating using CALC functions:
When solving in a screen while using the ZOOM function, results may differ in value from that shown in the example (coordinate values).

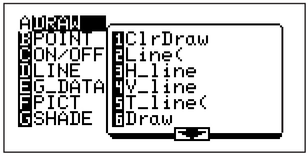


## (10) Shading

The calculator is equipped with a function to shade a specified range (SHADE function). This function is valid only for rectangular coordinates.
The following steps explain how to shade the area designated by this function.

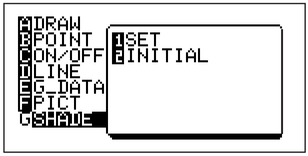
The SHADE menu is located in the DRAW menu.

- Press [2ndF] [DRAW].

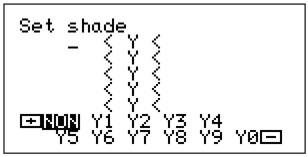



- Press [G].

The display shows two sub-menu items.
[1 SET]: To set the shade function.
[2 INITIAL]: To cancel the shade setting.
Used to return to the initial graph display.




- To set the shade function, press [1].




< Meaning of symbols on display >

| _ < Y < |
|---|

Initial cursor position

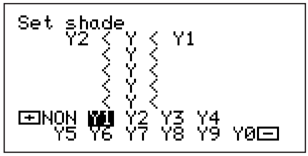
- The display shows the left and right sides of "Y", and the cursor is located on the left of those symbols. "Y" indicates the shading range. The shaded area will be larger than the value input on the left ("□" < Y) of "Y" and smaller than the value input on the right (Y < "□") of "Y".
- The cursor indicates the position where a selected equation number is entered.
To input an equation number, select from Y1 to Y9, and Y0 displayed at the bottom of the display. (The cursor is positioned on [NON] indicator in the initial display condition. This means that selection has not been made.)
Move the cursor to the selected equation using [+] [−].
To move the cursor in the left-to-right direction, use [◀] [▶].

* The touch pen can also be used to select Y1, etc.

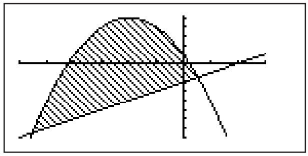
- A maximum of 5 settings can be made on the SHADE screen.
  Settings and their meanings (There are 3 shading patterns as shown below.)
  - Y1 <Y < Y2 (Shading of area larger than Y1 and smaller than Y2)
  - <Y < Y2 (Shading of area smaller than Y2)
  - Y1 <Y (Shading of area larger than Y1)

The following steps shade the area smaller than Y1 and larger than Y2.

1. Press [2ndF] [DRAW] [G] [1] to display the screen shown previously.
2. Press [−] [−]. Make sure that “Y2” appears on the left side of “Y”.
3. Press [▶] to move the cursor to the input position (“Y2<Y<_”) of the upper bound function.
4. Press [−] to input “Y1” on the right side of “Y”.

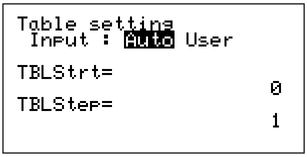



5. Press [GRAPH]. This returns to the graph display. The specified area on the graph will be shaded, as shown on the right.



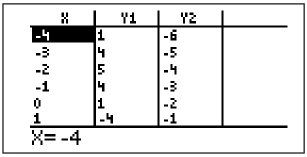
* If an invalid graphing function (Y1 to Y9, and Y0 functions with “=” sign in non-highlighted condition) is selected for the shading function, the entry is invalid.

## (11) Displaying tables (See page 121 for details.)




- A table is a chart of values yielded by a function (Yn) for values of X.
- There are two methods to create tables. In one method, the entry of a function automatically produces a table. In the other method, values are manually entered for X.
- To produce a table, it is necessary to display the TABLE SET screen. The TABLE SET screen is used to enter information necessary for a table display, such as whether to use the automatic table function or to manually input values, and the start value and table step.

1. Press [2ndF] [TBLSET] [▼].
   Specifies the automatic table production mode.
2. Press [(—)] 4 [ENTER].
   Sets "-4" in Table Start.
3. Press 1 [ENTER].
   Sets "1" in Table Step.
4. Press [TABLE].
   Displays a table.

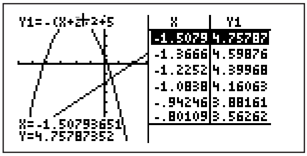



Equations for Y1 and Y2 have been entered; therefore, no value can be entered for the next column.

- Move the cursor pointer in the left-to-right direction by using [◀] [▶]. While setting tables, pressing [▶] [▶] [▶] [▶] displays Y4 on the right end of the display, and the Y1 column disappears. As a result, the screen shows X, Y2, Y3 and Y4 (only when Y3 and Y4 are in the equation and graphing is valid).
- Move the cursor pointer in the vertical direction by using [▲] [▼]. In the above screen, when [▲] is pressed, "-5" appears in the X column, and "1" disappears. The screen can be scrolled even outside the display range.

## (12) Split screen

- The split screen displays both a graph and a table at the same time.
  In the table set display (see above), press [2ndF] [SPLIT].
- The screen changes to the display shown on the right.
  The cursor pointer is located on the graph, and the coordinates of the cursor pointer location are highlighted in the table.




- The table screen shows X and Y1. They indicate the number of the equation on which the cursor pointer is located.
- When the cursor pointer is moved to the graph Y2 using [▲] or [▼], the Y1 display changes to the Y2 display, and the table shows the Y2 value for X.
  In the split screen, the TRACE mode is active.
- To exit from the split screen, press [2ndF] [QUIT].

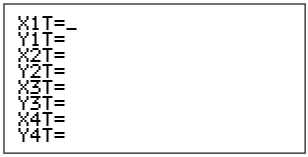
# 4. Parametric Graphing

The parameter graph mode can display graphs of defined equations (X = X(t), Y = Y(t)) using three parameters (variables). To display the calculated points, the calculator increases the T interval of Tstep and executes calculation. When the parameter coordinates are set, press [X/θ/T/n] to input T. You may draw up to 2 graphs in parameter graph.

**<Example>**

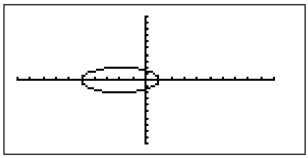
Graph "X = 3 sin T - 2", "Y = 2 cos T".

1. Set parametric coordinates.
   Press [2ndF] [SET UP] [E] [2].
2. Input equations.
   Press [+−×÷] [Y=] key to display screen to the right.
   Input "3 sin T - 2" to "X1T" and "2 cos T" to "Y1T".
   Press 3 [sin] [X/θ/T/n] [−] 2 [ENTER] 2 [cos] [X/θ/T/n] [ENTER].




* To change the graph size, reset the WINDOW value (see page 104) or execute ZOOM (see page 100).

3. Plot graph.
   Press [GRAPH] to plot graph.



* In the CALC functions of the parametric coordinate system, only Value (numeric value) is valid. Other functions, such as Intsct, Minimum, etc., used in the rectangular coordinate system are not provided.

* All trigonometric functions within a function equation are calculated using the angle unit (Deg, Rad or Grad) specified in the SET UP menu. Set angle unit system according to use.

# 5. Polar Coordinate Graphs

A polar coordinate graph shows coordinates with distance r from the origin point and positive-value angle θ from the X axis.
When the polar coordinate graph mode is selected, pressing [X/θ/T/n] enters the value of θ.

**<Example>**

To draw a polar coordinate graph of cosθ:

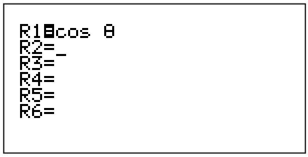
1. Set to the polar coordinate graph mode

Press [2ndF] [SET UP] [E] [3].

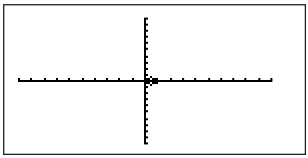

2. Entering equations.
   In the polar coordinate graph mode, the equation input screen (press [ ] [Y=]) allows a maximum of six equations (R1 to R6) to be entered.
   When [Y=] is pressed, the cursor pointer positioned at [R1].

   Enter the equation.

Press [COS] [X/θ/T/n] [ENTER].

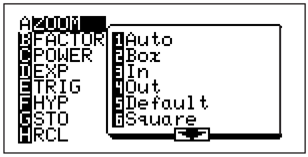



3. Drawing graphs.
   Press [GRAPH]. A small oval graph appears on the display, as shown on the right.
   The oval graph results because the display pitches of the X and Y axes are not the same.
   (The default X and Y range settings are valid for an initial graph display.)

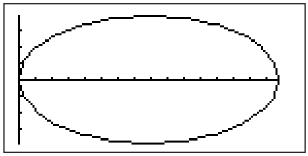


4. Setting suitable ranges
   The calculator features a function that allows easy range setting for graphing various equations. The following shows how this function is used to set the most suitable range for the above graph.

- Press ZOOM.
- Press A 1.




- The fully zoomed graph appears on the screen as shown on the right.



* In the polar coordinate graph mode, the trace, zoom and other functions can be used in the same way as for the X-Y coordinate graph mode. However, the CALC menu only has the VALUE function (numerical calculation function, obtaining R for the input value of θ).

# 6. Sequence Graphing

- The calculator is equipped with a sequence graph mode that can display regulated sequences (arithmetic and geometric) which can be expressed using function equations as graphs.
- The sequence graph mode can register or simultaneously draw three graph equations u(*n*), v(*n*) and w(*n*).
- Variables u, v, and w for use in graphs are entered as 2ndF u (secondary function of 7), 2ndF v, and 2ndF w. Variables are input in lower-case.
- X/θ/T/n in the sequence graph mode is for the input of *n*.

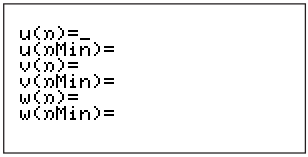
**<Example>**

There is the following arithmetical progression as a sequence.

3, 6, 9, 12, 15, 18….

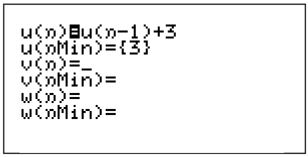
Since the general term u(*n*) of this sequence can be expressed as “u(*n*–1) + 3”, we will draw a graph with changes of *n* up to 10.

1. Set sequence graph mode (select [4 Seq] in the SET UP menu).
   Press 2ndF SET UP E 4 (+ − × ÷) Y=.
   The screen shown on the right will appear.

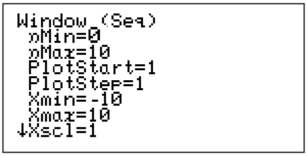


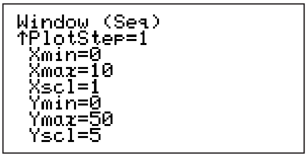

2. Input equation.

- Since the cursor pointer is positioned at u(*n*), the graph equation is entered as is.
  Press 2ndF u ( X/θ/T/n − 1 ) + 3 ENTER.
- The cursor will move one line below to “u(*n*Min)”.
- u(*n*Min) is the value of u(*n*) when the value of n is Min (minimum). In this case, it is 3.
- The screen shown to the right appears when pressing 3 ENTER and entry is complete (in this example, input of equations v(*n*) and w(*n*) is not necessary).



3. Set graph display screen size prior to graphing

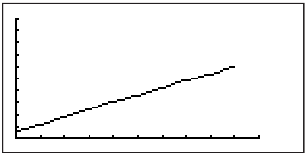



- Press the WINDOW key to display the screen shown to the right.
- Since the cursor pointer is positioned at "*n*Min", input *n*Min = 0 and *n*Max = 10 by pressing 0 ENTER 10 ENTER.
- Since Plotstart and Plotstep are the graph start point and increment of *n*, input 1 ENTER 1 ENTER.
- Next, input set values for X axis (horizontal axis) and Y axis (vertical axis).
- Press 0 ENTER 10 ENTER 1 ENTER, set Xmin = 0, Xmax = 10, and Xscl = 1
- Press 0 ENTER 50 ENTER 5 ENTER, set Ymin = 0, Ymax = 50, and Yscl = 5

* The first screen displays variables up to Xscl. Press ENTER to automatically open the following screens.

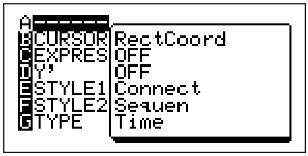
4. Graphing



- Press the GRAPH key to display the previous sequence graph.
- Normally, graphs are plotted using lines. However, graphs can also be plotted using dots or dotted lines depending on the data you wish to graph (see CHAPTER 4 "10. Selecting a Line Type of Graph" on page 103 for changing settings).
- Two types of variables (u to w(*n*-1) and u to w(*n*-2)) can be displayed using sequence graphs. When setting the two types of variables, it is necessary to input two values for the initial values u(*n*Min), v(*n*Min) and w(*n*Min) (for example, when entering 1 and 3 for u(*n*Min), enter "u(*n*Min) = {1,3}", separating numerical values with ",").
- In the Seq graph mode, 5 types of graph formats can be selected.
- These formats can be selected by accessing the FORMAT menu. See CHAPTER 4 "7. FORMAT Setting" on page 97 for details.
- **Notice on the COB-Web graph:**
  To trace the COB-Web graph in the sequence graph mode, it is not possible to touch a desired point on the graph using the pen and directly move the cursor to that position. Additionally, the display contents in the table on the split screen may vary from those in the normal table.

# 7. FORMAT Setting

These are various settings for operating the GRAPH screen.
The following describes the sub-menus in detail.
Pressing 2ndF FORMAT displays the screen shown on the right.




[G TYPE] appears only when the sequence coordinate graph mode is selected.

[A – – – – – – –] — Current format setting display screen.

[B CURSOR]

[1 Rect Coord] — To set to the rectangular coordinate graph mode. The location selected by the trace or other function is indicated by X and Y coordinates displayed at the bottom of the graph. (In the parametric system, the T indication is added.)

[2 Polar Coord] — To set to the polar coordinate graph mode. The location selected by the trace or other function is indicated by r and θ displayed at the bottom of the graph. (In the parametric system, the T indication is added.)

[C EXPRES]

[1 ON] — Displays a graph equation on the graph screen.

[2 OFF] — Does not display a graph equation on the graph screen.

[D Y’]

[1 ON] — Displays a numeric derivative (dy/dx) on the graph screen.

[2 OFF] — Does not display a numeric derivative (dy/dx) on the graph screen.

[E STYLE1]

[1 Connect]— To connect calculation points of a graph equation to create a graph. (Line indication).

[2 Dot] — Displays calculation points of a graph equation (Dot indication).

[F STYLE2]

[1 Sequen] — To set to the sequential graphing mode. (Graphs are drawn one at a time, in order.)

[2 Simul] — To set to the simultaneous graphing mode. (Two or more graphs are drawn at the same time.)

[G TYPE] (Valid only when the sequence coordinate graph mode is selected in SET UP. This indication does not appear in other modes.)

[1 Web] — Set to the COB-Web graph plot mode. To set u(*n*–1) to the X axis, and u(*n*) to the Y axis.

[2 Time] — To set *n* to the X axis, and u(*n*), v(*n*) and w(*n*) to the Y axis.

[3 uv] — To set u(*n*) to the X axis, and v(*n*) to the Y axis.

[4 uw] — To set u(*n*) to the X axis, and w(*n*) to the Y axis.

[5 vw] — To set v(*n*) to the X axis, and w(*n*) to the Y axis.

# 8. Entering Functions

- To enter functions, press [Y=] to display the function input screen, then enter expressions (an equation must be entered to display a graph).
- This calculator supports a total of four coordinate systems for the graphing function. (X-Y, parametric, polar, sequence — SET UP menu)
- The input screen and number of functions that can be stored in memory varies depending on the mode. (One of the following screens appears when [Y=] is pressed.)

X-Y

```
Y1=_
Y2=
Y3=
Y4=
Y5=
Y6=
Y7=
Y8=
```

```
Y3=
Y4=
Y5=
Y6=
Y7=
Y8=
Y9=
Y0=_
```

Memory capacity: 10 equations

Parametric

```
X1T=_
Y1T=
X2T=
Y2T=
X3T=
Y3T=
X4T=
Y4T=
```

```
X3T=
Y3T=
X4T=
Y4T=
X5T=
Y5T=
X6T=
Y6T=_
```

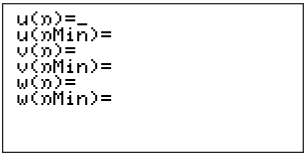
Memory capacity: 12 equations

Polar

```
R1=_
R2=
R3=
R4=
R5=
R6=
```

Memory capacity: 6 equations

Sequential

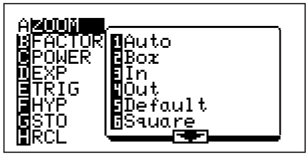



Memory capacity: 3 equations
(u(*n*), v(*n*), w(*n*)) and 3 lists
(u(*n*Min), v(*n*Min), w(*n*Min))

- In each function input screen, the cursor pointer indicates the equation number where an input can be made.
- When a function input screen is opened, the cursor appear on the right of the "=" sign of the top equation number.
- When a function is entered, the cursor pointer moves to the next character.
- Pressing ENTER completes the entry of the function to the equation number. At the same time, the cursor pointer moves to the equation number immediately below.
- The "=" sign of the equation for which an input is made becomes "=" (highlighted). This indicates that the graphing function is valid. (When GRAPH is pressed, the graph of the highlighted equation is drawn.)
  When the graph display is not necessary, use ◄, ►, ▲, and ▼ to move the cursor to the "=" sign of the selected equation number, and press ENTER. This changes the sign to "=" to indicate that the graphing function is inactive.
- If an equation does not fit in a single line, it automatically wraps to the beginning of the next line. (When the one line edit mode is selected.)
- X/θ/T/n is used to enter a variable in each of the above modes.
- Pressing X/θ/T/n allows the input of X in the X-Y coordinate system, θ in the polar coordinate system, T in the parametric coordinate system, and *n* in the sequence coordinate system.
- To delete or change an entered expression, move the cursor to the correction position using ◄, ►, ▲, and ▼, and make necessary changes.

# 9. Zoom Functions

- The ZOOM menu contains instructions that enable the changing of the display range of the graph screen.
- To use the zoom function, press ZOOM.




[A ZOOM] – To change the display range without numeric input such as range designation.

[B FACTOR] – To change display range by inputting zoom factors for X and Y axes.

[C POWER], – [D EXP], [E TRIG] , [F HYP] For automatic optimum screen settings for graphing powers, trigono metric functions and hyperbolic functions.

[G STO] – To store zoom settings (window settings) in memory.

[H RCL] – To recall stored window data and to return to the display that was shown before zooming was activated.

- A sub-menu appears on the right half of the display for each of menu items A to H.
- The sub-menu items have the following functions.

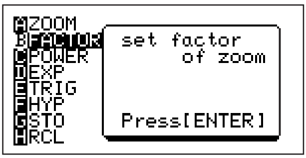
[A ZOOM]

| | | |
|---|---|---|
| [1 Auto] — | To set to the automatic scale mode. (Matches Ymin-Ymax relation to Xmin-Xmax relation.) | When [Auto] is selected in the graph display mode, a graph is automatically re-drawn according to the new window information. |
| [2 Box] — | To enlarge a section specified by the rectangular box to a full-screen display | When [Box] is selected, the display returns to the graph screen. When the upper left corner of the rectangular box is specified and then the lower right corner is specified, a new display area is set. |
| [3 In] — | To enlarge a graph according to the X and Y zoom factors set by [B FACTOR]. | When [In] is selected in the graph display mode, a graph is re-drawn according to the new window information (factor data). |
| [4 Out ]— | To reduce the size of a graph according to the X and Y zoom factors set by [B FACTOR]. When moving the cursor pointer before displaying “In” and “Out” described above, enlargement and reduction is executed so that the cursor pointer is the center of the screen. | When [Out] is selected in the graph display mode, a graph is re-drawn according to the new window information (factor data). |

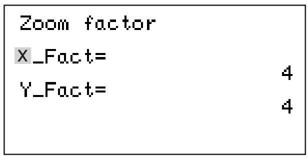
| | |
|---|---|
| [5 Default] — To set the graphing function to the standard display settings (default settings). • The default settings vary in the four modes. | When [Default] is selected in the graph display mode, a graph is re-drawn according to the default window data. |
| [6 Square] — To set the same scale for the X and Y axes. • The Y-axis scale is adjusted according to the X-axis scale. | When [Square] is selected in the graph display mode, a graph is re-drawn according to the new window information. |
| [7 Dec] — To set each screen dot to "0.1". | When [Dec] is selected in the graph display mode, a graph is re-drawn according to the new window information. |
| [8 Int] — To set each screen dot to "1". | When [Int] is selected in the graph display mode, a graph is re-drawn according to the new window information. |
| [9 Stat] — To display all points of statistical data. | When [Stat] is selected in the graph display mode, a graph is re-drawn according to the new window information. |

[B FACTOR] To adjust the X and Y axis zoom factors, and display the settings.
Key operations: Pressing ZOOM B displays the following screen.

Display changes




ENTER →




- When the above screen (zoom factor input screen) appears, the cursor is located over "X" of "X_Fact".
- Enter a numeric value for the X axis zoom factor, and press ENTER.
- The entered value is displayed at the lower right side of the "X_Fact =" indication. The cursor moves to "Y".
- Set the zoom factor for the Y axis.
- To exit from this screen, press 2ndF QUIT.
- The zoom factors set on this screen are used in the zoom in and out functions described previously. A graph cannot be re-drawn by setting FACTOR only.

[C POWER] [D EXP] [E TRIG] [F HYP]

- These menus change the display variables to settings suitable for drawing graphs of powers [C POWER], [D EXP], trigonometric functions [E TRIG] and hyperbolic functions [F HYP].
- To use these functions in the graph display mode, select an appropriate item from the ZOOM menu and press ENTER. The previous graph is replaced by a new graph according to the new window settings.
- The EL-9650's preset graph ranges are as follows.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| [C POWER] – | [1 $X^2$] | [D EXP] – | [1 $10^X$] | [E TRIG] – | [1 sin X] | [F HYP] – | [1 sinh X] |
| | [2 $X^{-1}$] | | [2 $e^x$] | | [2 cos X] | | [2 cosh X] |
| | [3 $\sqrt{X}$ ] | | [3 log X] | | [3 tan X] | | [3 tanh X] |
| | | | [4 In X] | | [4 $\sin^{-1}$ X] | | [4 $\sinh^{-1}$X] |
| | | | | | [5 $\cos^{-1}$ X] | | [5 $\cosh^{-1}$X] |
| | | | | | [6 $\tan^{-1}$ X] | | [6 $\tanh^{-1}$ X] |

- For trigonometric functions, each of the Deg, Rad and Grad modes has its range settings.
- These key operations are valid only in the rectangular coordinate graph mode.

[G STO]

| | |
|---|---|
| 1:Sto Win ....... To store the current window information. Only one set of data can be stored. | When [Sto Win] is selected in the graph display mode, the window information is stored, then the graph display mode reactivates. |

[H RCL]

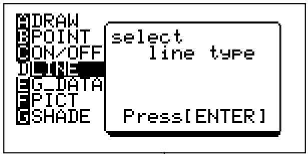
| | |
|---|---|
| 1:Rcl Win ....... To recall the window information stored by the Sto Win instruction. | When [Rcl Win] is selected in the graph display mode, a graph is drawn according to the stored window information. |
| 2:Pre Win ...... To re-draw a graph according to the window information that was valid prior to the execution of the zoom function. If the zoom function has not been used, specifying this will draw a graph according to the default settings. | When [Pre Win] is selected in the graph display mode, a graph is re-drawn according to the window information that was valid prior to the execution of the zoom function. |

# 10. Selecting a Line Type for a Graph

- The calculator has five kinds of lines (Solid line (–), Dotted line (…), Bold line (▬), Locus (-o-), Dot (○)) for drawing graphs.
- The type of line can be selected on the DRAW menu.
  It is possible to set a desired line type for equations in the different graph coordinate systems (four kinds in total).

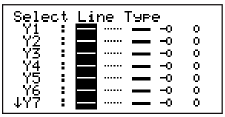
- To select a line type, do the following.

1. Press 2ndF, DRAW, D. (The menu [D LINE] allows you to set a desired line type.)
2. Press ENTER.
   As shown in the figures below, a list containing the equation number in each coordinate system and line type will appear on the screen.

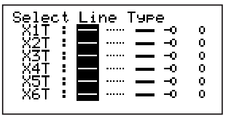



ENTER

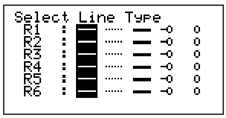
X–Y*1



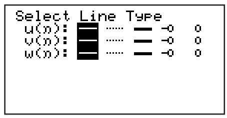

Parametric

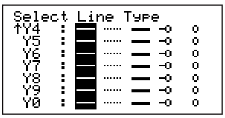



Polar




Sequential



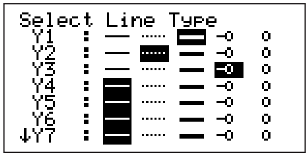

* The highlighted part on the screen expresses the current line type setting.
* The cursor flashes on the solid line of the first line (top of the screen).
* In the rectangular coordinate system, equations may exist on two pages. A "↓" mark is displayed at the left of the equation on the bottom line of the screen. (To show Y8, Y9 and Y0, press 2ndF ▼ or press ▼… to move the cursor sequentially.)
* The initial line type is a solid line (–).

**<Example>**

To set Y1: Bold line, Y2: Dotted line, and Y3: Locus line in the rectangular coordinate system.

Assume that the screen marked *1 on the previous page is already displayed.

1. Sets [Y1] to bold line.
   Press ► ► ENTER ▼.
2. Sets [Y2] to dotted line.
   Press ◄ ENTER ▼.
3. Sets [Y3] to locus line.
   Press ► ► ENTER.




   If the contents you have set are correct, press 2ndF QUIT to return to the previous screen.

* If the equation is deleted or if no equation is input, the solid line is set.

- For other three coordinate systems, the same procedure is applied to set the type of line.

# 11. Setting a Window

- The word, “WINDOW”, stands for a graph display screen.
- Using this screen, it is possible to set several ranges (X, Y, θ...) for the window. Changing the window ranges can be used to clarify the trend of the entire graph or to enlarge an important part of the graph.
- Press WINDOW to display any of the following screens corresponding to the currently set coordinate system.

- Input a numeric value while the cursor is displayed and press (ENTER) to set it.

### Rectangular coordinate system:

Xmin/Xmax: X-axis minimum and maximum values

Xscl: X-axis scale (Same contents apply to the Y-axis.)

```
Window (Rect)
 Xmin=-10
 Xmax=10
 Xscl=1
 Ymin=-10
 Ymax=10
 Yscl=1
```

### Parametric coordinate system:

The values below are applied to this coordinate system in addition to those in the rectangular coordinate system.

Tmin/Tmax: T minimum and maximum values

Tstep: Cursor pointer step value during tracing

```
Window (Param)
 Tmin=0
 Tmax=6.283185307
 Tstep=1.308996939E-1
 Xmin=-10
 Xmax=10
 Xscl=1
↓Ymin=-10
```

```
Window (Param)
↑Tstep=1.308996939E-1
 Xmin=-10
 Xmax=10
 Xscl=1
 Ymin=-10
 Ymax=10
 Yscl=1
```

### Polar coordinate system:

The values below are applied to this coordinate system in addition to those in the rectangular coordinate system.

θmin/θmax: θ (angle) minimum and maximum values

θstep: Cursor pointer step value during tracing

```
Window (Polar)
 θmin=0
 θmax=6.283185307
 θstep=1.308996939E-1
 Xmin=-10
 Xmax=10
 Xscl=1
↓Ymin=-10
```

```
Window (Polar)
↑θstep=1.308996939E-1
 Xmin=-10
 Xmax=10
 Xscl=1
 Ymin=-10
 Ymax=10
 Yscl=1
```

### Sequential coordinate system:

The values below are applied to this coordinate system in addition to those in the rectangular coordinate system.

*n*Min/*n*Max Maximum and minimum values of the sequential variable (*n*)

PlotStart/PlotStep: Start and step values of the variable (*n*) for drawing graph

```
Window (Seq)
 nMin=1
 nMax=10
 PlotStart=1
 PlotStep=1
 Xmin=-10
 Xmax=10
↓Xscl=1
```

```
Window (Seq)
↑PlotStep=1
 Xmin=-10
 Xmax=10
 Xscl=1
 Ymin=-10
 Ymax=10
 Yscl=1
```

# 12. Draw Operations

- The DRAW menu allows you to draw points or lines, and to save or call up the graph or pixel data.
- There are two kinds of drawing methods; one allows you to draw a point or line by directly touching a desired point on the screen and the other allows you to specify it by manually inputting data.

  Press 2ndF DRAW on the graph screen.

  Move the cursor pointer directly to a desired location on the graph screen where you wish to draw a point or line.

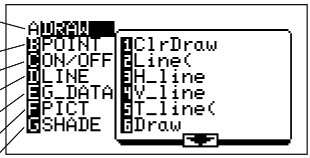
  Press 2ndF DRAW on other screens.

  A selected DRAW menu is displayed on the screen. Specify the coordinates of a desired location where you wish to draw a point or line. For example, to draw a point at (2, 3), input Point (2, 3) on the screen and press ENTER. The point can be seen on the screen immediately after the graph screen has been opened.

## (1) Draw menu configuration

Press 2ndF DRAW to display the following screen.

Used to draw and delete a line or function on the graph screen.
Used to draw and delete a point on the graph screen.
Used to turn ON/OFF the display of function equation.
Used to select a line type of the graph.
Used to save and call up the graph data.
Used to save and call up the graph picture.
Used to shade a specified area.



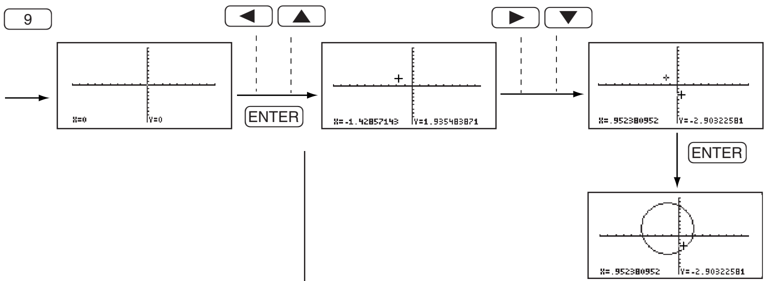
The following key operations show those after 2ndF DRAW A have been pressed.

**[A DRAW]**

| | Function | Key operations and display |
|---|---|---|
| [1 ClrDraw] | Deletes all points, lines, or pictures drawn using the DRAW menu. | (Graph display screen)<br>Press 1 to delete the draw data and to redisplay only the graph.<br>(Other screens)<br>Press 1 to display the message “ClrDraw” and press ENTER to proceed to delete the data. (At this time, the message, “Done”, showing that the data deletion has been performed will appear instantaneously on the screen.) |
| [2 Line( ] | Draws a line between the specified two points. | (Graph display screen)<br>Press 2 to display the cursor pointer on the graph screen. Use ◀ ▶ ▲ ▼ to move the cursor pointer to a desired location where you wish to start drawing of a line and press ENTER. Next, move the cursor pointer to a location where the line ends and press ENTER to draw a line between specified two points. (Using the same procedure, you can draw any number of lines subsequently.)<br>To cancel the mode, press CL.<br>(Other screens)<br>Press 2 to display the message “Line (”. Input the start and end coordinates of a line and press ENTER to draw the line on the graph screen.<br>The following syntax is used to draw a line.<br>[Line ($\underbrace{2, 3}$, $\underbrace{5, 6}$)]<br>Coordinates of line start point — Coordinates of line end point |

| | | |
|---|---|---|
| [3 H_line] | Draws a horizontal line at a specified location. | (Graph display screen)<br>Press 3 to return to the graph display screen where the cursor pointer is displayed. Using ◀ ▶ ▲ ▼, move the cursor pointer to a desired location and press ENTER to fix it. (Using the same procedure, you can draw any number of horizontal lines subsequently.)<br>* To cancel the horizontal line draw screen, press CL.<br>(Other screens)<br>Press 3 to display the message "H_line". Input the coordinates of a location where you wish to draw a horizontal line and press ENTER to draw it on the graph screen.<br>The following syntax is used to input the coordinates.<br>[H_line 5]<br>(Horizontal line is drawn at "Y=5".) |
| [4 V_line] | Draws a vertical line at a specified location. | The same key operations used to draw a H-line are used to draw a vertical line. However, to specify the coordinates, the following syntax is used.<br>[V_line 6]<br>(V_line is drawn at "X=6".) |
| [5 T_line(] | Draws a tangential line at the point on the graph. | (Graph display screen)<br>Press 5 to display the cursor pointer on the graph. Using ◀ ▶, move the cursor pointer to the desired location on the graph and press ENTER to draw a tangential line or input a numeric value (X-axis coordinate value) to draw a tangential line corresponding to the X-axis coordinate of the graph.<br>* Use ▲ ▼ to change the selection of graph to be displayed.<br>(Other screens)<br>Press 5 to display the message "T_line (". Input a graph equation and X-axis coordinate value where you wish to draw a tangential line and press ENTER to draw the tangential line on the graph screen. |

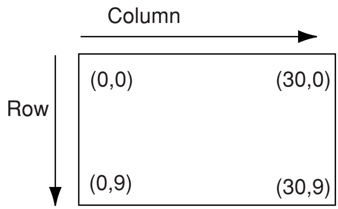
| | | |
|---|---|---|
| | | The following syntax is used to draw a tangential line.<br>[T_line (Y1, 3)]<br>Equation on which tangential line is drawn. X-axis coordinate value<br>(Tangential line is drawn at (X=3) on the graph Y1.) |
| [6 Draw ] | Draws an additional graph of the function equation on the graph screen. | (All screens)<br>Press 6 to display the message "Draw_".<br>For example, to draw the graph for "$X^2$", do the following.<br>Press X/θ/T/n $x^2$: The message, "Draw $X^2$", will appear.<br>Press ENTER. Graph for "$Y=X^2$" is drawn on the graph screen.<br>* It is also possible to specify a function equation from "Y1 to Y9", and Y0 which are already registered. |
| [7 Shade(] | Draws two specified function graphs and shades the area between them. | (All screens)<br>Press 7 to display the message "Shade (_".<br>Enter the lower limit equation and upper limit equation in order and press ENTER to shade the area between the two equations.<br>For example, "Shade ($2X^2$–5, X)" means that two graphs for "$Y=2X^2$–5" and "Y=X" are drawn and the area "$2X^2$–5 < Y < X" is shaded.<br>* It is also possible to specify function equation numbers which are already registered. The shade drawn here will disappear when redrawing the graph.<br>* It is also possible to specify shading by inserting the value of the x axis after the equation. For example, input shade ($2X^2$–5, X,-1,1) to shade between "$2X^2$–5<Y<X" and X = - 1 to 1. |
| [8 Draw Inv] | Draws a graph for the inverse function.<br>* The inverse function is a graph which is symmetric to the graph for "Y=X". | (All screens)<br>Press 8 to display the message "Draw Inv".<br>Input a function equation for which you wish to draw its inverse function or specify the equation number which is already registered. Press ENTER to draw the inverse function graph for the given function.<br>For example, "Draw Inv sin X" draws an inverse function of "sin X". |

| | | |
|---|---|---|
| [9 Circle(] | Draws a circle on the graph screen. | (Graph screen)<br>Press 9 to display the cursor pointer on the screen. Using ▲ ▼ ◀ ▶, move the cursor pointer to the center of the circle which you wish to draw and press ENTER to set the center. Next, move the cursor pointer to a location to determine the radius of that circle and press ENTER to draw the circle on the screen.<br><br>(Other screens)<br>Press 9 to display the message “Circle (”. Input the coordinates of the center and radius in order and press ENTER to draw the circle.<br>For example, Circle (2, 3, 4) draws the circle with a radius of 4 at coordinates (2, 3).<br>Center coordinates<br>Radius |
| [0 Text(] | Writes a character on the graph screen. | (All screens)<br>Press 0 to display the message “Text (_”. Input a location (column, row) and the desired text and press ENTER to write the text on the screen. For example, “Text (5, 1, “ABC”)” writes ABC with an origin of column No. 5 and row No. 1.<br>* The ranges in which you can specify the row and column are shown below.<br>* To specify a character string, ” is used (press MATH E 3). |

- * Lines, points, and curves drawn by the Draw menu are handled as pictures. Therefore, they cannot be traced.
- * Graphs drawn by the Draw menu are automatically cleared if any screen settings are changed. To save the graph, use the Sto Pict menu.
- * For example, to input Y1 for specifying a function equation, press [VARS] [A] [ENTER] [A] [1].
  To input "ABC" for Text function, press [MATH] [E] [3] [2ndF] [A-LOCK] [A] [B] [C] [ALPHA] [MATH] [E] [3].

## Row and column definitions for text input:

You may specify the coordinates where you wish to start writing text. (0 to 9 for row and 0 to 30 for column)




**[B POINT]**

- Draws and deletes a point on the graph screen.
- There are two operation methods. One is to directly move the cursor pointer to a location on the graph screen where you wish to insert a point. The other is to call a relevant command on the graph screen and to directly input the coordinates to draw or delete a point.
  Use Pnt ON or CHG (coordinates) or Pxl ON or CHG (coordinates) when inputting coordinates.

* X and Y coordinates should be separated by a comma (,).

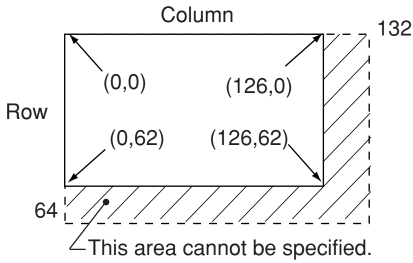
[1 Pnt ON] Draws a point on the specified graph screen.

[2 Pnt OFF] Deletes a point on the specified graph screen. (Points (dots) making up the graph or coordinate axis can also be deleted.)

[3 Pnt CHG] Changes the display status of a point on the specified graph screen. (Deletes the point when it is displayed and draws the point when it is not displayed.)

* For Pnt ON, Pnt OFF and Pnt CHG, input by specifying coordinates of the X and Y axis. For example, Pnt ON (5,3) defines points at coordinates X = 5, Y = 3

[4 Pxl ON] Draws a point at a specified location by inputting the column and row. Column and row definitions are shown to the right.
Column: 0 to 126 (For the split screen (see CHAPTER 4 "15. Useful Functions" on page 124), only a range of 0 to 64 can be specified.)
Row: 0 to 62

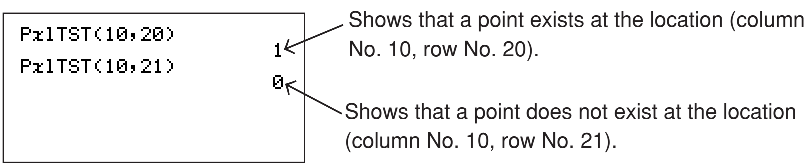



[5 Pxl OFF] Deletes a point at a location specified by column and row. (Points (dots) making up the graph or coordinate axis can also be deleted.)

[6 Pxl CHG] Changes the display status of a point at a location specified by column and row. (Deletes the point when it is displayed and draws the point when it is not displayed.)

[7 Pxl TST] Displays "1" when a point exists at a location specified by column and row and "0" when no point exists.

The following screen will appear.



**[C ON/OFF]**

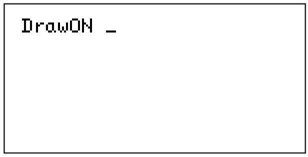
Makes the graph equation valid or invalid in units of equation. (For the rectangular coordinate system, this equals “Y1=” (Valid) and “Y1=” (Invalid).)

[1 Draw ON] Makes the graph equation valid. (An “=” mark in the specified equation will be highlighted.)

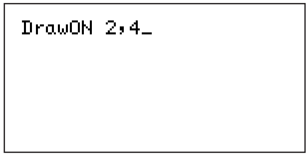
**<Example>**

To specify [1 Draw ON]:

1. Press 2ndF DRAW C 1.

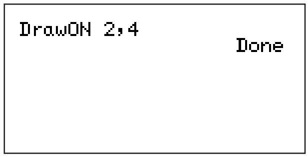



2. Press 2 , 4 to input an equation number.
   Make the second and fourth (“Y2” and “Y4” for the rectangular coordinate system) valid.




Press ENTER

This message shows that operation has been performed.




[2 Draw OFF] Makes the graph equation invalid. (An “=” mark in the specified equation will not be highlighted.)
Perform the above operations to specify Draw OFF.

**[D LINE]**

Used to specify a type of line for the graph. (For details, see CHAPTER 4 “10. Selecting a Line Type for a Graph” on page 103.)

**[E G_DATA]**

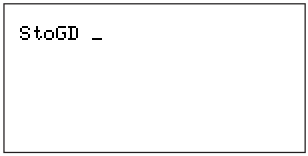
[1 Sto GD]

Saves the graph data. The graph data can be saved to any of ten memory spaces G_Data 1 to G_Data 9, and G_Data 0. Graph data which can be saved are the equation data (in all rectangular, polar, parametric, and sequential coordinate systems) and window settings.

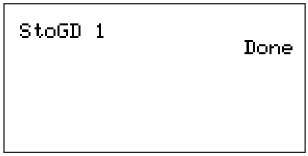
If the memory was previously used, new data overwrites the old data.

Operation:

1. Press 2ndF DRAW E 1. The screen shown to the right will appear, allowing you to input the memory number where you wish to save the data.




2. Press 1 ENTER. Graph data is saved to G_Data 1. The screen shown on the right will appear, showing that the graph data has been saved to G_Data 1.




[2 Rcl GD]

Calls up the saved graph data.

Specify the graph data number to call up the graph which is already saved. (If the graph data is called up, that graph data overwrites the graph screen and window data currently displayed on the screen.)

If the graph database to be called up cannot be found, the relevant error message will appear on the screen.

Operation:

1. Press 2ndF DRAW E 2. The screen shown to the right will appear, allowing you to call up the graph data.

```
RclGD _
```

2. Press 1 ENTER. G_Data 1 is called up. The screen shown on the right will appear, showing that G_Data 1 has overwritten the current screen contents.

```
RclGD 1
                Done
```

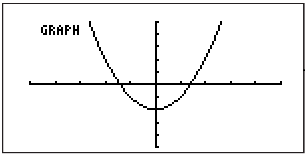
**[F PICT]**

[1 Sto Pict]

Saves the function graph and coordinate axes currently displayed, and points, lines, and graphs drawn by the DRAW function as pictures. Graphic pictures are saved to any of ten memory spaces, Pict 1 to Pict 9, and Pict 0. If the memory where the Pict data has been saved is specified, the new data overwrites the old data.

Operation:

To save the following graph to Pict 1, do the following.




2ndF DRAW F 1

```
StoPict _
```

1

```
StoPict 1_
```

ENTER

Graph is saved.

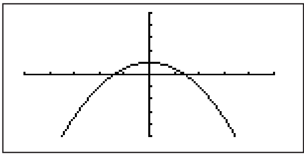
* The data to be saved as Pict data is like a hard copy of the screen and is completely different from the graph data. Even though the Pict data is called up, the data is handled as pictures, and therefore no function equations exist. (Tracing is also not possible.)

[2 Rcl Pict]

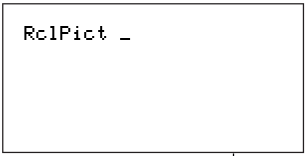
Calls up the saved Pict data by specifying it. The Pict data which is called up is overlapped on the current graph screen. If the Pict data to be called up is not found, the relevant error message will appear on the screen.

Operation:

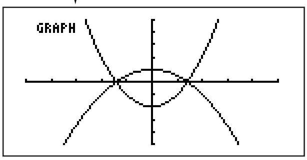
To call up the Pict 1 data which has been saved previously and overlap it on the graph currently being created, do the following.



2ndF DRAW F 2




1 ENTER




* In the above example, assume that the coordinate axes of the graph currently being created and the data corresponding to those of the Pict 1 data are the same.

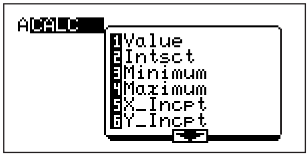
* In the above example, tracing of  is possible, however, tracing of the graph which is retrieved cannot be performed.

**[G SHADE]**

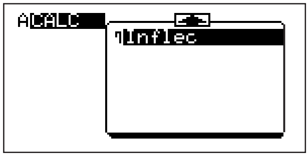
Shades an area specified by function equations. (For details, see CHAPTER 4 “3. Rectangular Coordinate Graphing : (10) Shading” on page 88.)

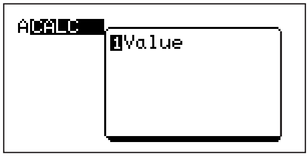
# 13. CALC Functions

- This function allows you to automatically calculate the position specified by the menu and move the cursor to that point.
- Press (2ndF) (CALC) to enter the CALC menu.
  When (2ndF) (CALC) are pressed, the screen shown to the right will appear.
- The CALC function has seven options, 1 to 7, which are described below.




- However, when Polar, Param, or Seq is selected, only Value appears as shown on the right.




[1 Value] ....... Calculates the Y-axis value corresponding to the X-axis value and moves the cursor pointer to that point on the graph.

[2 Intsct] ........ Calculates the intersection of two graphs and moves the cursor pointer to that point.

[3 Minimum] .. Calculates the minimum of the given function graph and moves the cursor pointer to that position.

[4 Maximum] . Calculates the maximum of the given function graph and moves the cursor pointer to that position.

[5 X_Incpt] .... Calculates the position where the function graph intersects the X-axis and moves the cursor pointer to that point.

[6 Y_Incpt] .... Calculates the position where the function graph intersects the Y-axis and moves the cursor pointer to that point.

[7 Inflec] ........ Calculates the inflection point of the function graph and moves the cursor pointer to that point.

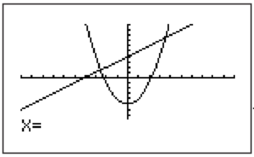
* Option 7 will not appear on the first screen. Press (▼) to scroll the screen.

**<Example>**

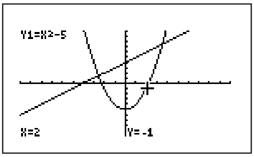
To select any of the above menu items, 1 to 7, press (2ndF) (CALC), and a desired number, 1 to 7. In the following examples, assume that “Y1=$X^2$–5” and “Y2=X+4” have been registered and EXPRES is ON.

[1 Value]:

Press [1].

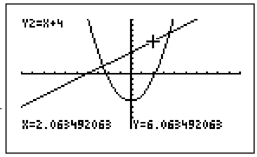



2 [ENTER]




The cursor pointer moves to the point “X=2” on the graph for “Y = $X^2$ –5”.

[▼] or [▲]



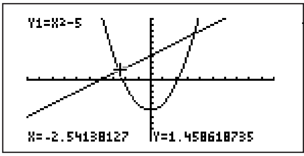

The cursor pointer moves to the graph for “Y = X+4”.

* As shown above, press [▼] or [▲] to move the cursor pointer between graphs. (Press [◄] or [►] to trace the cursor pointer on the graph.)

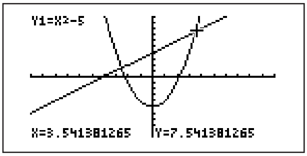
* X and Y coordinates will appear on the bottom of the screen.

[2 Intsct]:

Press [2].




If there is more than one intersection, press [2ndF] [CALC] [2] to move the cursor pointer to the next intersection.

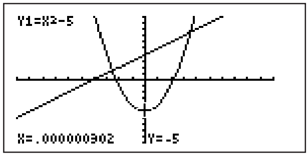



* To calculate the intersection if more than one graph is displayed, press [▲] or [▼] to move the cursor to another graph, and then press [2ndF], [CALC], and [2] again.

* If the intersection exists beyond the display range of the screen, only the coordinates will appear on the bottom of the screen. The cursor pointer will not appear when the X coordinate of that intersection is within the display range.

[3 Minimum]:

- Press [3].




The cursor pointer moves to the minimum point of the graph for "Y1 = $X^2 - 5$".

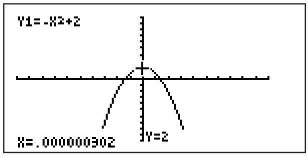
- At this time, the coordinates will appear on the bottom of the screen.
- To move to another graph, press [▼] or [▲].

If the minimum point cannot be calculated, the error message, "No Solution", will appear and show that the cursor pointer cannot be moved.

[4 Maximum]:

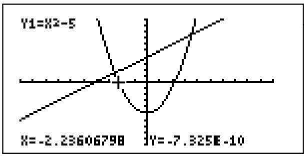
- Press [4].

- In the previous example, the maximum point cannot be calculated and therefore the error message "No Solution" will appear on the screen.
- If the graph "Y1 = $-X^2 + 2$" shown to the right is displayed, the cursor moves to the maximum point.

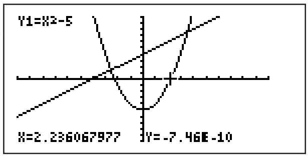



[5 X_Incpt]:

- Press [5].

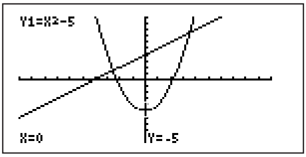



If there is more than one intersection, press [2ndF] [CALC] [5] to move the cursor pointer to the next intersection.



[6 Y_Incpt]:

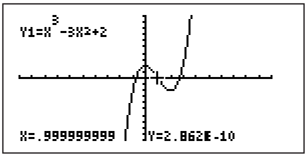
- Press 6.




[7 Inflec]:

- Press 7.

  In this example, assume that the cubic equation of “$Y1 = X^3 - 3X^2 + 2$” has been input.

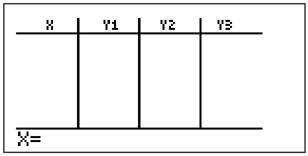



* When calculating using the CALC function:
When solving in a screen with the ZOOM function in use, results may differ in value from that shown in the example (coordinate values).

# 14. Tables

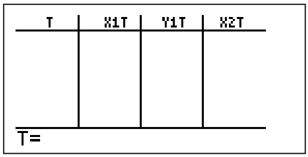
- The calculator allows you to illustrate the changes using the function equation and graph you have input. In addition to this function, it also has tables for showing a list of X and Y values.
- There are four kinds of tables available corresponding to the specified coordinate system (graph).

① Rectangular coordinate system



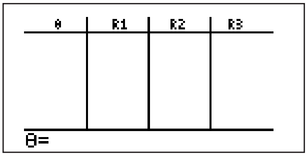

- The variable X is displayed in the left end column.
- For table values (Y), Y1 to Y3 are displayed on the first screen.
- To show values Y4 to Y9, and Y0, press ▶ to horizontally scroll the screen. (However, note that the variable X is always displayed in the left end column.)
- For values X, Y1 to Y9, and Y0, up to 7 digits, including a sign and decimal point can be displayed.
- A 10-digit value of the column where the cursor pointer is currently located is displayed on the bottom line of the screen.
- The cursor pointer can be moved using ◀ ▶ ▲ ▼.
- Non-input equation numbers and equations invalid for graphing will not be displayed in the above table.

② Parametric coordinate system



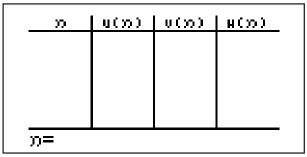

- The variable T is always displayed in the left end column.
- For table values, X1T, Y1T, and X2T are displayed on the first screen.
- To show values that follow X2T, press ▶ to horizontally scroll the screen.
- For values T and X1T and Y1T to X6T and Y6T, up to 7 digits, including a sign and decimal point can be displayed.
- A 10-digit value of the column where the cursor pointer is currently located is displayed on the bottom line of the screen.
- The cursor pointer can be moved using ◀ ▶ ▲ ▼.
- Non-input equation numbers and equations invalid for graphing will not be displayed in the above table.

③ Polar coordinate system




- The variable θ is always displayed in the left end column.
- For table values (R), R1 to R3 are displayed on the first screen.
- To show values R4 to R6, press ▶ to horizontally scroll the screen.
- For values θ, R1 to R6, up to 7 digits, including a sign and decimal point can be displayed.
- A 10-digit value of the column where the cursor pointer is currently located is displayed on the bottom line of the screen.
- The cursor pointer can be moved using ◀ ▶ ▲ ▼.
- Non-input equation numbers and equations invalid for graphing will not be displayed in the above table.

④ Sequential coordinate system



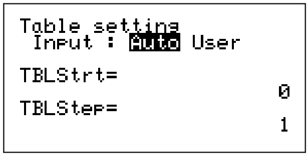

- The variable *n* is always displayed in the left end column.
- Tables values u(*n*), v(*n*), and w (*n*) are simultaneously displayed.
- For values n, u(*n*), v(*n*), and w(*n*), up to 7 digits, including a sign and decimal point can be displayed.
- A 10-digit value of the column where the cursor pointer is currently located is displayed on the bottom line of the screen.
- The cursor pointer can be moved using ◀ ▶ ▲ ▼.
- Non-input equation numbers and equations invalid for graphing will not be displayed in the above table.

## (1) Table Setting

- To display the table, press TABLE. (Note that it is essential to input an equation and set the table before using this function.)
- Table setting allows you to input data necessary for creating a table.
- Press 2ndF TBLSET to enter the table setting screen. (See the figure below.)
- The cursor pointer is initially located at “Auto”, showing the variable input method.

  Auto: Automatically creates a table using the function equation and given TableStart and TableStep values.

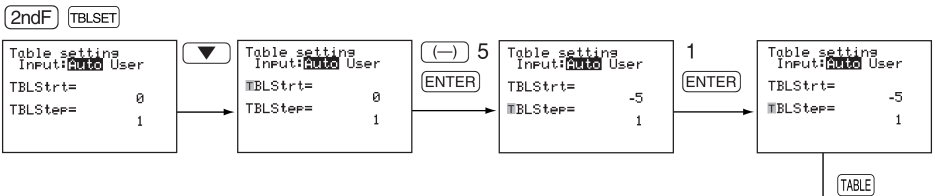
  User: Displays a blank table. As you input values for variable columns, table values are automatically calculated by the function equation to complete the table. Thus, although TableStart and TableStep inputs can be made when selecting User, set values will not be used.




- Press ◀ or ▶ to switch between “Auto” and “User”.
- TableStart is a start value of the variable in the table, and TableStep is a step value of the variable. Both are numeric values.

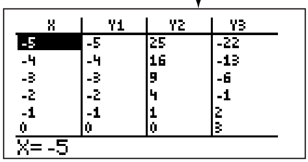
**<Example>**

To automatically create a table starting from -5 with a step of 1 in the X-Y coordinate after equations, “Y1 = X”, “Y2 = $X^2$”, and “Y3 = $-X^2 + 3$” have been input.



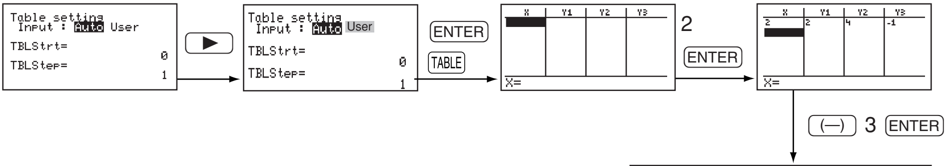

* After the table has been displayed, the screen can be scrolled vertically using ▲ or ▼.

* Even though the cursor is on the top or bottom line of the table, use of ▼ and ▲ is allowed. In this case, the table set screen is also changed with correspondence to the table display.

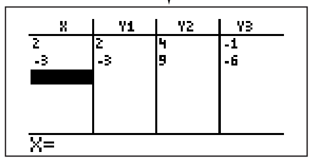


**<Example>**

To create a table in the User mode under the above conditions.




* An automatically created table on the user creation screen cannot be scrolled vertically.




# 15. Useful Functions

The calculator provides a rapid function which allows you to easily input a graph equation, window settings, and zoom settings while observing the graph screen. Pressing EZ enters the rapid function mode.

## (1) Rapid GRAPH

- For simple operations, you can select a desired equation from the built-in list in the calculator and draw its graph.
  This mode is valid only in the rectangular coordinate system.
- When EZ is pressed in other modes, an error occurs. (The error message “Rect-coordinate only available”, instantaneously appears on the screen.)
- 8 kinds and 51 types of equations listed below are built into the rapid graph function.

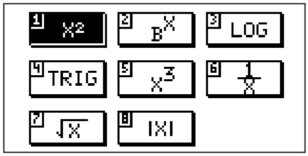
| | | | | | |
|---|---|---|---|---|---|
| RAPID GRAPH | $X^2$ | A) | $Y=AX^2$ | 1) | $Y=AX^2$ |
| | | | | 2) | $Y=X^2$ |
| | | | | 3) | $Y=3X^2$ |
| | | | | 4) | $Y=1/2\ X^2$ |
| | | | | 5) | $Y=-2X^2$ |
| | | B) | $Y=AX^2+B$ | 1) | $Y=AX^2+B$ |
| | | | | 2) | $Y=X^2+1$ |
| | | | | 3) | $Y=2X^2-1$ |
| | | | | 4) | $Y=-X^2+1$ |
| | | | | 5) | $Y=-2X^2-1$ |
| | | C) | $Y=A(X-H)^2+K$ | 1) | $Y=A(X-H)^2+K$ |
| | | | | 2) | $Y=2(X-1)^2+2$ |
| | | | | 3) | $Y=-2(X-1)^2+2$ |
| | | | | 4) | $Y=(X+2)^2-1$ |
| | | | | 5) | $Y=-(X+2)^2-1$ |
| | | D) | $Y=AX^2+BX+C$ | 1) | $Y=AX^2+BX+C$ |
| | $B^X$ | A) | $Y=B^X$ | 1) | $Y=B^X$ |
| | LOG | A) | Y=logX | 1) | Y=logX |
| | | B) | Y=Alog (X–H)+K | 1) | Y=Alog (X–H)+K |
| | | C) | Y=Aln (X–H)+K | 1) | Y=Aln (X–H)+K |
| | TRIG | A) | Y=Asin (BX–H)+K | 1) | Y=Asin (BX–H)+K |
| | | | | 2) | Y=2sin (-2X+π)+2 |
| | | | | 3) | Y=1/2sin (X–π/2)–1 |
| | | | | 4) | Y=-2sin (-2X+π)+2 |
| | | | | 5) | Y=–1/2sin (X–π/2)–1 |
| | | | | 6) | Y=sin (2X+π/2)+1 |
| | | | | 7) | Y=sin (2X–π/2)+1 |
| | | B) | Y=Acos (BX–H)+K | 1) | Y=Acos (BX–H)+K |
| | | | | 2) | Y=2cos (–2X+π)+2 |
| | | | | 3) | Y=1/2cos (X–π/2)–1 |
| | | | | 4) | Y=–2cos (–2X+π)+2 |
| | | | | 5) | Y=–1/2cos (X–π/2)–1 |
| | | | | 6) | Y=1/2cos (2X+π/2)+1 |
| | | | | 7) | Y=1/2cos (2X–π/2)+1 |
| | | C) | Y=Atan (BX–H)+K | 1) | Y=Atan (BX–H)+K |
| | | D) | Y=Asec (BX–H)+K | 1) | Y=Asec (BX–H)+K |
| | | E) | Y=Acsc (BX–H)+K | 1) | Y=Acsc (BX–H)+K |
| | | F) | Y=Acot (BX–H)+K | 1) | Y=Acot (BX–H)+K |
| | $X^3$ | A) | $Y=AX^3+BX^2+CX+D$ | 1) | $Y=AX^3+BX^2+CX+D$ |
| | | B) | $Y=A(X-H)^3+K$ | 1) | $Y=A(X-H)^3+K$ |
| | $\frac{1}{X}$ | A) | Y=A/X | 1) | Y=A/X |
| | | | | 2) | Y=1/X |
| | | | | 3) | Y=–1/X |
| | | B) | Y=A/(X–H)+K | 1) | Y=A/(X–H)+K |
| | | C) | Y=(AX+B)/(CX+D) | 1) | Y=(AX+B)/(CX+D) |
| | | D) | $Y=A/(X-H)^2+K$ | 1) | $Y=A/(X-H)^2+K$ |
| | $\sqrt{X}$ | A) | $Y=A\sqrt{BX}$ | 1) | $Y=A\sqrt{BX}$ |
| | | B) | $Y=A\sqrt{(BX-H)}$ | 1) | $Y=A\sqrt{(BX-H)}$ |
| | | C) | $Y=A\sqrt{(BX-H)}+K$ | 1) | $Y=A\sqrt{(BX-H)}+K$ |
| | | D) | $Y=\sqrt[A]{BX}$ | 1) | $Y=\sqrt[A]{BX}$ |
| | \|X\| | A) | $Y=A\|X-H\|+K$ | 1) | $Y=A\|X-H\|+K$ |

**<Example>**

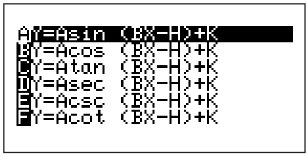
Input “Y1 = 2sin(-2X + π) + 2” using the rapid graph function.

1. Press (Y=) to open the equation input screen and place the cursor at [Y1].

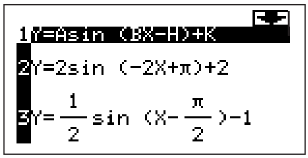

2. Press (EZ) to display the large classification screen for the equation.




3. Since the sine function is included in [TRIG], select [TRIG]. There are three methods shown below to select [TRIG].
   - Touch [4 TRIG] with the pen.
   - Press (4) (ENTER).
   - Press (▼) (ENTER). (Assuming the cursor pointer is initially located at $X^2$.)
   - The screen enters the medium classification screen on which actual equations are displayed.




4. To select the sine graph, move the cursor to A (current position) and press (ENTER).
   - The small classification screen shown to the right will appear.



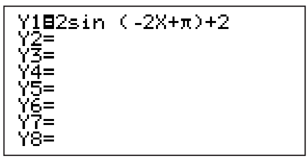

5. Press (2) (ENTER) to input a desired equation to Y1.

* At this time, pressing (GRAPH) immediately draws the graph. However, the equation selected using the rapid graph function does not have any graph range. Therefore, the graph is drawn based on the current window settings.

* To return to the normal function calculation screen from the rapid graph mode, press (2ndF) (QUIT).

* To return to the initial screen of RAPID GRAPH, press (CL).

* The entire equation cannot be displayed when the number of digits exceed one line. Use (◀)(▶) to check the equation.



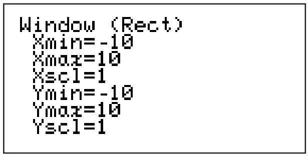
## (2) Rapid window

- This function is used to set the window settings by selecting any of the typical window settings built into the calculator.
- Regardless of the coordinate system, this function only sets the X and Y values.
- To set the rapid window, set the X-Window and Y-Window in that order.
- Pressing CL during setting of the rapid window returns to initial screen of the Rapid window. At this time, however, if setting of the X-Window has been completed, this setting affects the subsequent operation. (It is not necessary to set both the X- and Y-Window at the same time.)
- To return to the normal function calculation screen from the rapid window mode, press 2ndF QUIT.

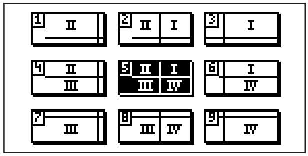
**<Example>**

To set the X-Window to (-10 <X<1, scl: 1) and Y-Window to (-10<Y<1, scl: 1) in the X-Y coordinate using the rapid window function, do the following.

1. Press WINDOW to open the window screen.
   The default settings will appear on the screen. (The settings which appear on the screen may vary depending on previous operations.)

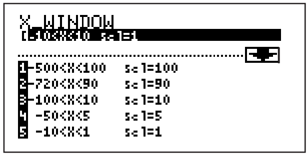



2. Press EZ.
   A selection screen, which clearly shows where the coordinate axes of the graph should be located, will appear. (Roman numerals indicate quadrants.)

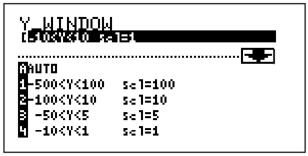


3. Select number 7 to set this example. There are the following three ways to select number 7.
   - Touch [ ].
   - Press 7 ENTER.
   - Press ◀ ▼ ENTER.

4. The X-Window selection screen will appear.
   The settings displayed on the top line (after C: ) are the current settings.
   The ⬇ mark at the upper right corner of the screen shows that the setting selection range exists after line 5. (To show line 6 and later, touch ⬇, press ALPHA ▼, or use ▼.)

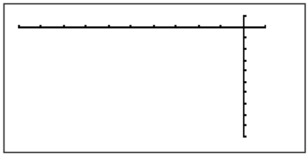



5. Press 5 ENTER (or directly touch [5]) to select line 5.
6. The Y-Window selection screen will appear.
   The current settings are displayed on the top line, like the X-Window selection screen.
   [A AUTO] allows automatic setting of the Y-Window corresponding to the X-Window.




7. Press 4 ENTER to select line 4.

* Pressing ENTER draws the graph based on the selected X- and Y-Window.



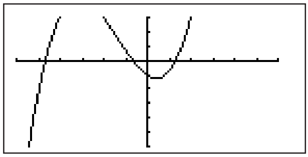
## (3) Rapid zoom

- The rapid zoom function allows you to easily enlarge or reduce the graph while referring to the reduced graph.
- To use this function, press EZ on the graph drawing screen.

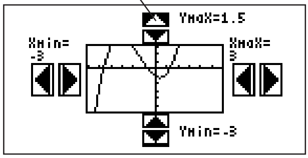
**<Example>**

When drawing a graph of the cubic equation, a part of the graph is not displayed. Move this part to the display area using the rapid zoom function.

1. To move the displacement point of the graph which cannot be seen currently to the screen and move the whole graph down, follow the next steps.

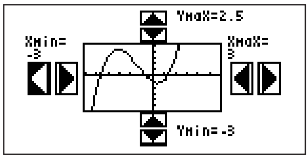


Initial position of the cursor pointer

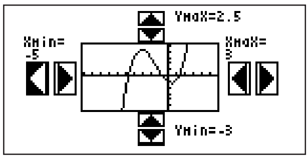



(Move the Y-axis to the center of the screen.)

2. Press (EZ).
   A reduced graph of the above graph will appear at the center of the screen.
3. First, lower the graph by touching (▲)(▲) … with the pen or pressing (ENTER) (ENTER)...
   Use [◀] [▶] [▲] [▼] at the top, bottom, left, and right of the screen show the axis to be extended.
   Touch any of these symbols or press a relevant key.
   If the cursor pointer is at the top of the Y-axis setting as shown, press (▼) or (▲) to move the cursor pointer along with the Y-axis and press (◀) or (▶) to move the cursor pointer along with the X-axis. (Use of pen-touching allows direct selection of a point where the cursor pointer is moved.)




4. Next, move the graph to the right by touching [◀] [◀] … with the pen or pressing (◀) (ENTER) (ENTER)....
   Move the cursor pointer to [◀] at the left of the screen and touch [◀] or keep (ENTER) pressed to gradually move the graph to the right.



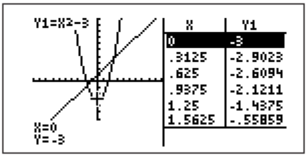

5. Press (GRAPH) to view the full graph.

* The initial screen that appears for Rapid Zoom may differ from that shown in the example, depending on the Window settings.

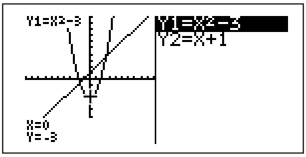
## (4) Split screen

- The calculator provides a split screen function which allows you to view the graph and table or the graph and graph equation at the same time.
- The screen is split vertically as shown below. This function is valid in all coordinate system modes.

Graph and table



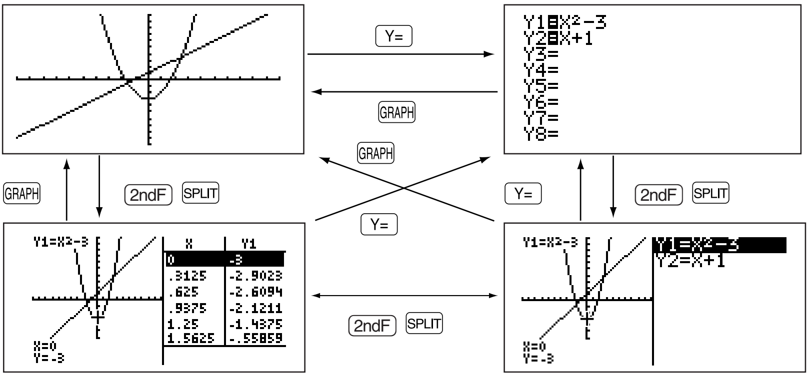

Graph and equation




* The area where the cursor is located is reversely displayed.

- To enter the split screen, press 2ndF SPLIT.
- When 2ndF SPLIT are pressed on the graph screen, the graph and table are displayed on the same screen.
- When 2ndF SPLIT are pressed on the equation input screen, the graph and equation are displayed on the same screen.

The following illustration shows these relationships.



- The split screen is always in the trace mode. Therefore, the cursor pointer appears on the graph. Accordingly, the coordinate values are reversely displayed in the table and the equation at which the cursor pointer is located is also reversely displayed.
- Using ◀ or ▶, move the cursor along the graph. (Values reversely displayed in the table are also changed accordingly.)
- When two or more graphs are displayed on the screen, a desired graph is selected using ▲ or ▼. (Accordingly, the table or equation on the right of the screen is also changed.)
- The table on the split screen does not relate to the table settings on the table full-screen.
- The table on the split screen is displayed in units of trace movement amount based on the cursor pointer position on the graph screen. When the table full-screen is displayed by pressing TABLE, a different table may appear on the screen.
- When the EXPRES or Y' is set to ON on the FORMAT menu, the equation or coordinates are displayed on the graph screen.
- Only equations whose graphs can be drawn are displayed on the split screen.
- Press GRAPH or TABLE on the split screen to display the full-screen of the graph or table. To exit the split screen, press any of other function keys.

## (5) Substitution graph

- The substitution graph allows you to input an equation using characters and variables, and substitute numeric values for the characters to draw its graph.
- The substitution graph is valid only in the rectangular coordinate system. Using this function, any number of numeric value sets can be substituted while referring to the graph drawing screen. This clearly shows the changes in the graph depending on numeric values. For example, the graph for "$Y1 = AX^3 + BX^2 + CX^2 - D$" is drawn by substituting numeric values for variables A, B, C, and D of the equation.

- 22 kinds of variables (characters), A to Z except for R, T, X, and Y can be used for the substitution graph.
- Up to seven variables (characters) can be used for one equation. (If the equation contains more than seven variables (characters), up to seven characters from the top of the equation are determined as variables and subsequent characters are ignored.)
- If you attempt to execute an equation containing no variables, the substitution graph becomes invalid and the error message, “NO VARIABLE”, appears on the screen.
- To input the equation, there are the following two methods after [Y=] has been pressed. After the equation has been input, the same operations apply to subsequent steps.

① Input an equation directly.

**<Example>**

Input “AX$^2$ + B” to “Y1”.

Press [Y=] (move the cursor to Y1), [CL] [ALPHA] A [X/θ/T/n] [$x^2$] [+] [ALPHA] B.

② Press [EZ] to select a desired equation from the equation list built into the rapid graph function (if the desired equation is included in the rapid graph function).

**<Example>**

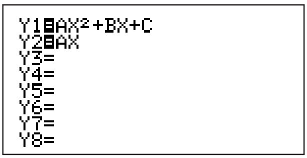
Input the same example above.

Press [Y=] (move the cursor to Y1) [CL] [EZ] [1] [ENTER] [▼] [ENTER] [ENTER].

**<Example>**

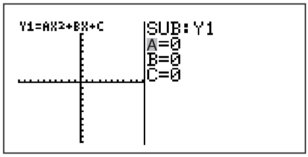
Substitute numeric values under the conditions that “Y1 = AX$^2$ + BX + C” and “Y2 = AX” have been input.

Equation input screen




The cursor pointer is located at Y1. Drawing of both graphs Y1 and Y2 is valid.

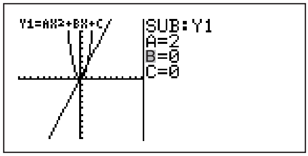
1. Press (2ndF) (SUB).




The substitution graph screen will appear. The equation on which the cursor pointer is located and its variables are displayed on the right of the screen.
If variables (characters) contain no values, the graph is not drawn.
If independent memories A to C contain any numeric values, the graph is drawn based on these values.

* If the equation (in this example, Y1) on which the cursor is located contains no variables, the substitution graph screen will not appear.

2. Press 2 (ENTER). (2 is input to A.)

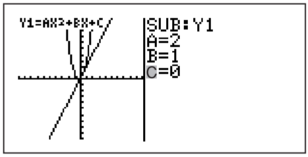



B

The graph for “Y1 = 2X$^2$” is drawn. (Since B and C have no values, they are ignored.)
At this time, the graph for Y2 is also drawn. Y2 also uses variable A which is used in Y1. Therefore, the drawing of the graph for Y2 is also valid.

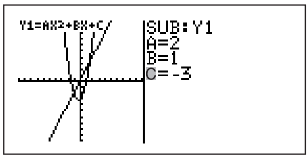
* If you need to draw only the graph for Y2, it is necessary to change variables (characters) or make the graph drawing invalid.

3. Press 1 (ENTER). (1 is input to B.)




The graph is changed from “Y1 = 2X$^2$” to “Y1 = 2X$^2$ + 1X”.

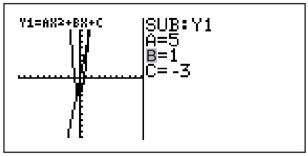
4. Press (—) 3 (ENTER). (-3 is input to C.)




Now, the graph for “Y1 = 2X$^2$ + 1X – 3” is drawn on the screen.

Next, change variable A from 2 to 5 and view how the graph changes.

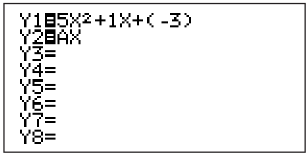
1. Press ▲ ▲ 5 ENTER. (The cursor is moved from C to A and 5 is input.)
   The slope of the graph becomes sharp.




* Accordingly, move the cursor and substitute other numeric values for variables to view how the graph changes.

* The trace function cannot be used in the substitution graph mode.
(When TRACE is pressed, the full-screen graph will appear.)

2. Press 2ndF EXE to return to the equation display screen.
   The equation is written based on the last numeric values input on the substitution graph screen.




* Once 2ndF EXE have been pressed, the screen cannot be returned to the previous substitution graph screen.

# CHAPTER 5
# MATRIX FUNCTIONS

## 1. Inputting a Matrix

- Up to ten files can be defined as matrices (each matrix can contain up to 99 rows and columns).

- The size may be defined in the range of 1 through 99. However, the overall size is limited according to the memory capacity.

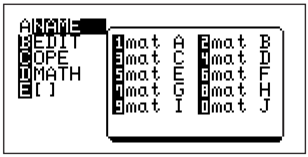
- To input a matrix, press MATRIX to enter the edit menu in the matrix mode. (A matrix which is already input can also be edited in the MATRIX edit mode.)

- For the input procedures, define a dimension (row × column) and enter numeric values for elements in sequential order.

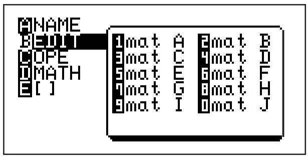
**<Example>**

Input a matrix $\begin{vmatrix} 4 & 3 & 1 \\ 5 & 2 & 6 \end{vmatrix}$ to mat A.

1. Press MATRIX to display the matrix menu.




2. Press B to display the edit menu.

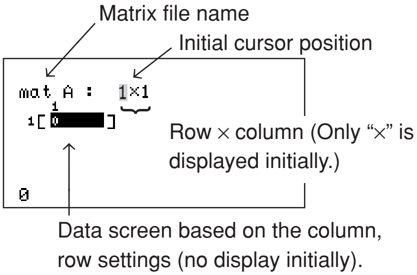



* The contents on the right portion of the screen are not changed. When a matrix name is selected on [A NAME] on the previous screen, that matrix name is copied to the home screen (screen immediately before pressing MATRIX ) and is used for calculation.

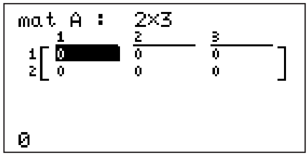
3. Press 1 to specify [1 mat A] as the matrix input file.

**Description of screen:**

The screen to the right shows the matrix column 1, row 1 being set.



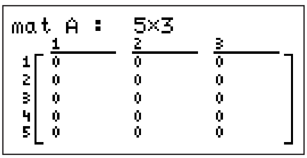

4. Define a dimension (row × column).
   This matrix is 2 rows × 3 columns. Press 2 ENTER 3 ENTER.



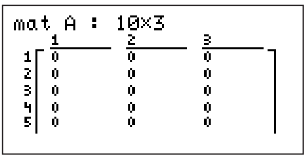

- Every time ENTER is pressed, the rows are made and then the columns are made. Accordingly, the cursor is also moved right and down automatically every time ENTER is pressed.
  Row number and column number are displayed on the screen.

- The maximum number of elements that may be displayed on one screen is 5 rows by 3 columns.
  To show other areas, press ◀, ▶, ▲, or ▼.

- Even though the data overflows the screen area, the row and column numbers are always displayed, making it easy to check the data location.
  The maximum parentheses display of a matrix differs according to contents as shown below.

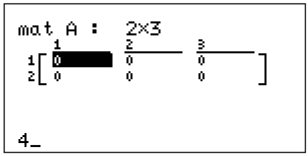



The above shows that all of the data are displayed on the screen.



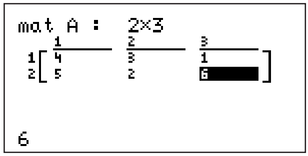

The above shows that the column data is displayed on the screen, but more rows of data exist on the bottom.

5. Input data sequentially. First, press 4.




- “4” is displayed on the bottom of the screen. The contents displayed on the bottom line show the data to be input in the cell where the cursor pointer is located.
- The order of the numeric value input is (1st row, 1st column), (1st row, 2nd column)..., (2nd row, 1st column), (2nd row, 2nd column)...and so on.

6. Press ENTER 3 ENTER 1 ENTER 5 ENTER 2 ENTER 6 ENTER to obtain this screen.




- At this time, the unit is in the edit mode. Press a numeric key and ENTER to overwrite “6”.
- To move the cursor pointer to the top of the defined dimension, press ▲.
- To use the touch pen on this screen, directly touch the desired numeric data to allow that data to be edited.
- Press after entry has been completed.

# 2. Matrix Calculations

Functions except for complex numbers can be used.
Additionally, [C OPE] and [D MATH] of the [MATRIX] menu include the special matrix functions.

**<Example>**

Assume that mat A is $\begin{vmatrix}1 & 5\\3 & 2\end{vmatrix}$ and mat B is $\begin{vmatrix}4 & -2\\3 & 9\end{vmatrix}$.
Calculate the addition of mat A and mat B, and the square of mat A.
The calculation is done on the home screen.

1. mat A + mat B
   [+−×÷] [CL] (Clears the home screen.)
   [MATRIX] [A] [1] [+] [MATRIX] [A] [2]

```
mat A+mat B_
```

2. Press [ENTER] to obtain the answer in the matrix format.

```
mat A+mat B
                 [[5  3 ]
                  [6  11]]
```

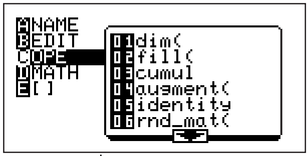
3. Square of mat A.
   [+−×÷] [CL]
   [MATRIX] [A] [1] [$x^2$] [ENTER]

```
mat A²
                [[16  15]
                 [9   19]]
```

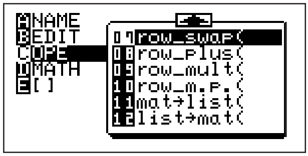
   If the answer matrix and the equation cannot be displayed on one screen, the equation disappears and only the answer is displayed.
   To show the part of the answer which cannot be displayed on the screen, press [◀], [▶], [▲], or [▼] to scroll the screen in a desired direction.
   Additionally, using the last answer function, the answer can be temporarily stored into a blank matrix file like “Ans ⇒ mat H”. After that, press [MATRIX] [B] [8] to display the list in the edit mode.

# 3. Calculations Using Special Matrix Functions

- The matrix menu includes the OPE, MATH, and [ ] calculation on the function menus.
- Pressing MATRIX C allows you to check the options included in the OPE menu.




▶ ALPHA ▼



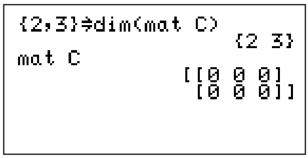

## (1) OPE

The following explains commands of the OPE menu, assuming that mat A is $\begin{vmatrix} 5 & 4 \\ 4 & 5 \end{vmatrix}$, mat B $\begin{vmatrix} 3 & 1 \\ 2 & 6 \end{vmatrix}$ and mat E $\begin{vmatrix} 5 & 2 & 3 \\ 4 & 9 & 2 \\ 1 & 5 & 6 \end{vmatrix}$.

[01 dim(] Used to define a matrix or check the contents.

**<Example>**

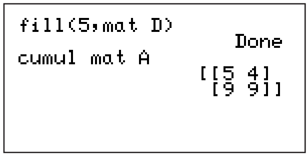
To define the dimensions of mat C as [2, 3]:
Entry: {2, 3} ⇒ dim (mat C)
Display: As shown to the right.
* "⇒" indicates STO.
* To specify mat C, press MATRIX A 3 (not B 3).




To check the contents of mat C:
The display shown to the right will appear when pressing MATRIX A 3 ENTER.
As described previously, it is also possible to define the matrix by pressing MATRIX B 3 2 ENTER 3 ENTER.

[02 fill(] Used to fill elements of the matrix with a specified value.

**<Example>**




To fill all elements of mat D with 5: (It is necessary to define the dimension before executing this function.)

Entry: fill (5, mat D)

Answer: $\begin{vmatrix} 5 & 5 \\ 5 & 5 \end{vmatrix}$

* The message, “Done”, will appear on the screen after calculation.

This answer is obtained by calling up mat D.

[03 cumul] Used to make a cumulative matrix.

**<Example>**

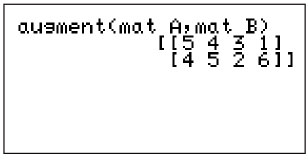
To make a  cumulative matrix of mat A:

Entry: cumul  mat A

Answer: $\begin{vmatrix} 5 & 4 \\ 9 & 9 \end{vmatrix}$

[04 augment(] Used to make an augmented matrix.

**<Example>**



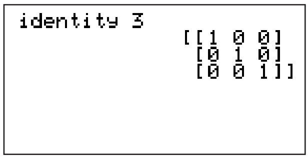

To make an augmented matrix of mat A and mat B:

Entry: augment (mat A, mat B)

Answer: $\begin{vmatrix} 5 & 4 & 3 & 1 \\ 4 & 5 & 2 & 6 \end{vmatrix}$

[05 identity] Used to make a unit matrix.

**<Example>**




To make a unit matrix containing 3 rows by 3 columns:

Entry: identity 3

Answer: $\begin{vmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{vmatrix}$

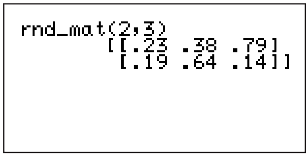
[06 rnd_mat(] Used to make a matrix by generating random numbers.

**<Example>**

To make a random matrix containing 2 rows by 3 columns (TAB setting: 2, FSE: set to FIX):

Entry: rnd_mat (2, 3)

Answer: $\begin{vmatrix} .23 & .38 & .79 \\ .19 & .64 & .14 \end{vmatrix}$




* Since this function generates random numbers, the actual answer you obtain may not match the above display.

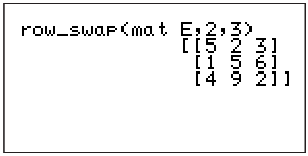
[07 row_swap(] Used to swap the data in two specified rows.

**<Example>**

To swap the 2nd and 3rd rows of mat E (FSE: set to FloatPt):

Entry: row_swap (mat E, 2, 3)

Answer: $\begin{vmatrix} 5 & 2 & 3 \\ 1 & 5 & 6 \\ 4 & 9 & 2 \end{vmatrix}$



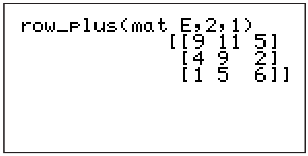

[08 row_plus(] Use to add specified row data to another specified row.

**<Example>**

To add the 2nd row to the 1st row of mat E:

Entry: row_plus (mat E, 2, 1 )

Answer: $\begin{vmatrix} 9 & 11 & 5 \\ 4 & 9 & 2 \\ 1 & 5 & 6 \end{vmatrix}$



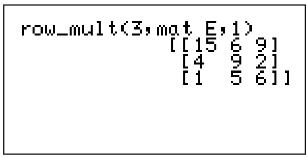

[09 row_mult( ] Used to perform scalar multiplication of elements in a specified row.

**<Example>**

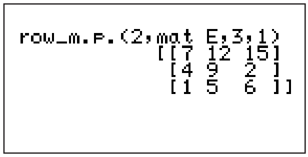
To multiple elements in the 1st row of mat E by 3:

Entry: row_mult (3, mat E, 1 )

Answer: $\begin{vmatrix} 15 & 6 & 9 \\ 4 & 9 & 2 \\ 1 & 5 & 6 \end{vmatrix}$



[10 row_m.p.( ] Used to perform scalar multiplication of elements in a specified row and add the result to another specified row.




**<Example>**

To multiple elements in the 3rd row of mat E by 2 and add the result to the 1st row:

Entry: row_m.p. (2, mat E, 3, 1)

Answer: $\begin{vmatrix} 7 & 12 & 15 \\ 4 & 9 & 2 \\ 1 & 5 & 6 \end{vmatrix}$

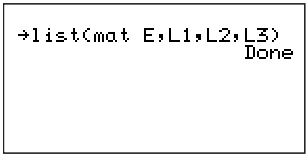
[11 mat→list( ] Used to make list data from the matrix data (makes a list corresponding to each column of the matrix)
This function is the same as mat→list (of the LIST, OPE menu)

**<Example>**

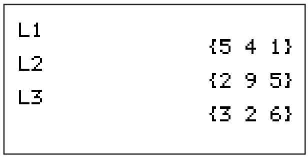
To make lists L1, L2, and L3 using mat E (mat E contains three columns):

Entry: mat→list (mat E, L1, L2, L3)

Answer: L1: {5 4 1}
L2: {2 9 5}
L3: {3 2 6}




* After the message “Done” has been displayed, press 2ndF L1 ENTER to sequentially call up the list to check it.



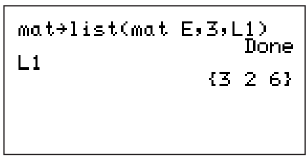

Additionally, it is possible to make a matrix from the specified column of the matrix.

**<Example>**

To make list L1 from the 3rd row of mat E:

Entry: mat→list (mat E, 3, L1 )

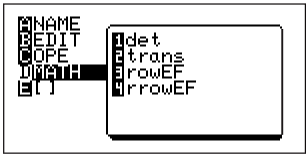
Answer: L1: {3 2 6}




* After the message “Done” has been displayed, 2ndF L1 ENTER to call up list L1 to check it.

[12 list→mat] Used to make matrix data from the list data (for details, see CHAPTER 6 “3. Special List Function Groups Built into the Menu” on page 148).
This function is the same as list→mat (of the LIST, OPE menu)

## (2) MATH




- Next, the special matrix function menu MATRIX is explained below.
- Press MATRIX D to open the matrix MATH menu. This menu contains options 1 to 4.

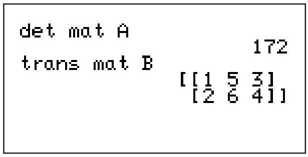
[1 det] Used to calculate the determinant from the matrix to obtain the solution.
This command can be used only when the number of rows and columns are the same.

**<Example>**

To calculate the determinant of mat A: $\begin{vmatrix} 3 & 4 & 2 \\ 8 & 3 & -6 \\ -5 & 2 & 2 \end{vmatrix}$:

Entry: det mat A

Answer: 172




[2 trans] Used to calculate the transposed matrix (rows and columns of the matrix are swapped).

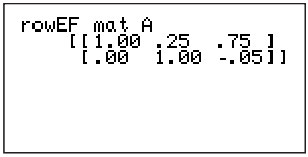
**<Example>**

To calculate the transposed matrix of mat B: $\begin{vmatrix} 1 & 2 \\ 5 & 6 \\ 3 & 4 \end{vmatrix}$:

Entry: trans mat B

Answer: $\begin{vmatrix} 1 & 5 & 3 \\ 2 & 6 & 4 \end{vmatrix}$

[3 row EF] Used to calculate the row-echelon form of the matrix.




**<Example>**

To calculate the row-echelon form of mat A: $\begin{vmatrix} 3 & 6 & 2 \\ 4 & 1 & 3 \end{vmatrix}$

(TAB: 2, FSE: set to FIX):

Entry: rowEF mat A

Answer: $\begin{vmatrix} 1.00 & .25 & .75 \\ .00 & 1.00 & -.05 \end{vmatrix}$

[4 rrow EF] Used to calculate the reduced row-echelon form of the matrix.

**<Example>**

To calculate the reduced row-echelon form of mat A: $\begin{vmatrix} 2 & 3 & 18 \\ 3 & -3 & -3 \end{vmatrix}$:

Entry: rrowEF mat A

Answer: $\begin{vmatrix} 1 & 0 & 3 \\ 0 & 1 & 4 \end{vmatrix}$

```
rrowEF mat A
             [[1 0 3]
              [0 1 4]]
```

The use of rrow EF makes it possible to solve simultaneous equations.

To solve the following simultaneous equations, follow these steps.

$x + 2y - z = 3$

$2x - 3y + z = 0$

$3x - y - z = -2$

- First, determine the coefficients of the matrix and make matrix B containing 3 rows by 4 columns. $\begin{vmatrix} 1 & 2 & -1 & 3 \\ 2 & -3 & 1 & 0 \\ 3 & -1 & -1 & -2 \end{vmatrix}$
- Next, calculate the matrix B using rrow EF as shown below. $\begin{vmatrix} 1 & 0 & 0 & 2 \\ 0 & 1 & 0 & 3 \\ 0 & 0 & 1 & 5 \end{vmatrix}$
- As a result, the following solutions are obtained.

  $1 \times x + 0 \times y + 0 \times z = 2 \qquad x = 2$

  $0 \times x + 1 \times y + 0 \times z = 3 \qquad y = 3$

  $0 \times x + 0 \times y + 1 \times z = 5 \qquad z = 5$
- To solve simultaneous equations using rrow EF, a matrix containing the numbers of variables and equations is required.

## (3) Calculation using [ ]

• Next, the calculation using [ ] is explained.

Press [MATRIX] [E] to open the [ ] menu.

Square brackets [ ] are provided on the matrix function screen "E:" to define a matrix representation. By selecting sub-menu item 1 or 2, the matrix representation can be copied onto the home screen.

**< Example >**

Used when creating a matrix directly from the standard function display screen.

Key operation to create $\begin{vmatrix} 4 & 3 \\ 2 & 5 \end{vmatrix}$ is as follows:

[⊞] [MATRIX] [E] [1] [MATRIX] [1] 4 [,] 3 [MATRIX] 2 [MATRIX] [1] 2 [,] 5 [MATRIX] [2] [MATRIX] [2] [ENTER]

# CHAPTER 6
# LIST FUNCTIONS

- A list is handled as numeric data containing multiple numeric values in parentheses.
- A list is normally used in equations and calculations.
  The calculator has six registration areas, L1 to L6, as memory areas.
  Additionally, all lists L1 to L6 are registered as one set of list data. Up to ten sets of list data, L_Data 1 to L_Data 9, and L_Data 0 can be stored.
- To input data and create a list, select the general function calculation screen.

**<Example>**

Assume that the data 1, 3, 2, and 9 and the other data 5, 4, 6, and 3 exist. Store both of the sets of data to L1 and L2, respectively.

1. [+−×÷] [CL]
   Selects the general function screen and clears it.

```
{1,3,2,9}
```

2. [2ndF] [{] 1 [,] 3 [,] 2 [,] 9 [2ndF] [}]
   Puts one set of data in parentheses. A comma (,) must be put between numeric values.
3. The data input is now completed. Next, to store the above data to list L1, follow these steps.
   To resister the data, use [STO].
   Stores the data to list L1.
   [STO] [2ndF] [L1] [ENTER].

```
{1,3,2,9}⇒L1
          {1 3 2 9}
```

   In the same manner, to create list L2, follow these steps.
   [2ndF] [{] 5 [,] 4 [,] 6 [,] 3 [2ndF] [}] [STO] [2ndF] [L2] [ENTER]

```
{1,3,2,9}⇒L1
          {1 3 2 9}
{5,4,6,3}⇒L2
          {5 4 6 3}
```

- To specify the list number, press [2ndF] [L1] (or [L2] to [L6]) [ENTER]. The specified list is displayed on the screen.

# 1. List Calculations Using List Number

- Calculations between lists and calculations using functions can be performed.
- It is also possible to store complex numbers in the list.

**<Example>**

Calculation examples using lists L1 and L2 created previously.

| Example | Key operation | Display |
|---|---|---|
| To input the result of the above 10 × L1 to L3: | 10 [×] [2ndF] [L1] [STO] [2ndF] [L3] [ENTER] | 10*L1⇒L3<br>{10 30 20 90} |
| sin L3 | [sin] [2ndF] [L3] [ENTER]<br>* Angle mode is degree. | sin L3<br>{.173648177 .5 .34202…<br>The above display, "....", shows that the answer cannot be displayed within one line and the remaining part exists on the right. (To show the remaining part of the answer, press [▶] [▶]…[▶]. The numeric values will scroll to the left and the message, "...", will also appear at the left end. |
| L1 + L2 | [2ndF] [L1] [+] [2ndF] [L2] [ENTER] | L1+L2<br>{6 7 8 12} |

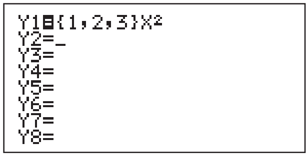
| | | |
|---|---|---|
| To add new data 7 to L1 | 7 STO 2ndF L1 ( 5 ) ALPHA : 2ndF L1 ENTER *1<br>* To add new data, it is put in the 5th term since data is already input until the 4th term.<br>* If a number of 6 or more is input instead of 5 in the above operation and ENTER is pressed, an error occurs.<br>* If a number of 4 or less is input in ( ) in the above operation, the old data in the corresponding term is overwritten by 7. | 7⇒L1(5):L1<br>{1 3 2 9 7} |
| To add L1 which has been updated in step 4 to L2: L1 + L2 | 2ndF L1 + 2ndF L2 ENTER<br>* Since the L1 contains five terms and L2 contains four terms, addition cannot be done. | ERROR 05<br>[Dimension ]<br>◀,▶:Goto error<br>CL :Quit |
| √L2 | 2ndF √ 2ndF L2 ENTER | √L2<br>{2.236067977 2 2.4494… |

*1 : If a colon ( : ) is used, data may continue to be entered in more than one term.

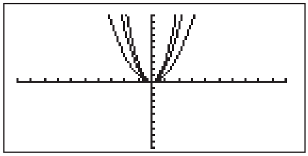
# 2. Drawing a Function Graph Using a List

**<Example>**

To draw the graph for "Y = {1, 2, 3} $x^2$" in the rectangular coordinate system using the list containing {1, 2, 3}, follow these steps.



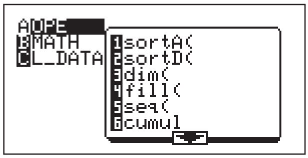

1. First, input the equation.
   [Y=] opens the equation input screen.
2. Move the cursor to Y1. (If any equation is already input, clear it.)
3. [2ndF] [{] 1 [,] 2 [,] 3 [2ndF] [}] [X/θ/T/n] [$x^2$]
   [ENTER]
4. Press [GRAPH].



Three graphs are drawn as shown to the right.
{1, 2, 3} $X^2$ means that three graphs for "$Y=1X^2$", "$Y=2X^2$", and "$Y=3X^2$" are drawn.
The window settings in the graph shown to the right are default values.

* After "L1 = {1, 2, 3}" is entered, "Y = $L1X^2$" can also be designated.

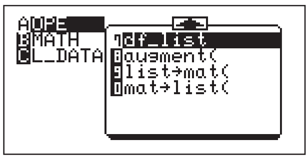
# 3. Special List Function Groups Built into the Menu




Press [2ndF] [LIST].

[A OPE] ....... Menu for functions related to transformation
[B MATH] ..... Menu for list calculation functions
[C L_DATA] . Menu for saving/loading of list data

## (1) OPE




"↓" showing that sub-menu items exist below No. 6 is displayed. Press [▶] [ALPHA] [▼] to show all menus.
There are ten options available in the OPE.
Assume that lists, L1 : {6, 4, 5} and L2 : {3, 9, 8} have already been stored. Each of the functions is explained in the following examples.

[1 sort A(] Used to sort the data in the list in ascending order.

**<Example>**

To sort list L1 in ascending order:

Entry: sort A (L1)

Answer: {4 5 6}

* It is also possible to sort more than one list at the same time. To do so, separate lists with a comma (,).

Entry: sort A (L1, L2)

Answer: L1: {4 5 6}
L2: {9 8 3}

At this time, the first list (L1 ) is sorted in ascending order, however, subsequent lists are sorted according to the sorted terms in the first list.
(All lists are not sorted in ascending order.)

[2 sort D(] Used to sort the data in the list in descending order.

**<Example>**

To sort list L1 in descending order:

Entry: sort D (L1)

Answer: {6 5 4}

“Done” will be displayed on the execution screen of both sortA and sortD. Press 2ndF L1 ENTER to check list contents.

[3 dim(] Use to set or return the dimension (the number of terms) of the list.

**<Example>**

To display the dimension of list L1:

Entry: dim (L1 )

Answer: 3

**<Example>**

To set the dimension of list L3:

Entry: 4 STO dim (L3)

Answer: {0 0 0 0}

Display: 4

* When executing the dim command using an existing list, a new list is created using the entered data.

[4 fill( ] Used to substitute a specified value for all terms in the specified list for which numeric values are input.

**<Example>**

To substitute 5 for list L3:

Entry: fill (5, L3)

Numeric value for substitution    List name for substitution

Answer: {5 5 5 5}

"Done" will be displayed on the execution screen. Press 2ndF L3 ENTER to check list contents.

[5 seq(] Used to input an equation and make a list by changing variables ranging from a start value to an end value by a set increment. Include "x" in the equation as a variable.

Entry: seq (equation, start value, end value, increment)

Increment can be omitted. (The increment will be set to "1".)

**<Example>**

To make a list based on calculation values when the variable X of the equation "X+2" is changed from 0 to 4 in increments of 1:

2ndF LIST A 5 X/θ/T/n + 2 , 0 , 4 )

```
seq(X+2,0,4)_
```

ENTER →

```
seq(X+2,0,4)
          {2 3 4 5 6}
```

[6 cumul] Used to cumulate terms in the list sequentially from the first term .

**<Example>**

To cumulate list L1:

Entry: cumul L1

Answer: {6 10 15}

6 6+4 6+4+5

[7 df_list] Used to calculate the difference between adjacent terms in the list to make a new list.

**<Example>**

To calculate the difference between adjacent terms in list L1 and make a list :

Entry: df_list L1

Answer: {-2 1}

4–6 5–4

[8 augment(] Used to make an augmented list of two lists.

**<Example>**

To make an augmented list of L1 and L2:

Entry: augment (L1, L2)

Answer: {6 4 5 3 9 8}

[9 list→mat(] Used to make a matrix from the list data.

**<Example>**

To make matrix A from lists L1 and L2:

Entry: list→mat (L1, L2, mat A)

Calls up the matrix file name.

Key operations: MATRIX A 1

Answer: mat A [[6 3]<br>[4 9]<br>[5 8]]

* "Done" will be displayed on the execution screen.

* To call up the contents of the matrix: MATRIX A 1 ENTER.

The terms of each list are input to each column of the matrix. The use of complex numbers is not allowed.

This function is the same as "list→mat" of the MATRIX menu.

[0 mat→list(] Used to make list data from the matrix data.

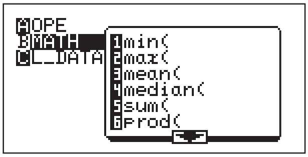
(For details, see CHAPTER 5 "3. Calculations Using Special Matrix Functions" on page 139.)

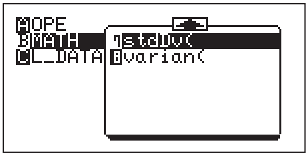
This function is the same as "mat→list" of OPE menu.

## (2) MATH

In this section, assume that L1 = {6, 4, 5} and L2 = {3, 9, 8} are already input.

1. Press 2ndF LIST B to display the MATH sub-menu.
2. Press ► ALPHA ▼ to open the next page.
   There are eight options available in the MATH menu.




[1 min ( ] Used to find the minimum value in the list.

**<Example>**

To find the minimum value in list L1:

Entry: min (L1)

Answer: 4

* The minimum value of more than one list can be calculated at the same time. In this case, lists are separated by a comma (,).

[2 max ( ] Used to find the maximum value in the list.

**<Example>**

To find the maximum value in list L1:

Entry: max (L1)

Answer: 6

* In the same manner as described above, multiple lists can be calculated at the same time.

[3 mean ( ] Used to calculate the average value of the list.

**<Example>**

To find the average value of list L1:

Entry: mean (L1)

Answer: 5

[4 median ( ] Used to find the median value in the list.

**<Example>**

To find the median value in list L2:

Entry: median (L2)

Answer: 8

[5 sum ( ] Used to sum terms in the list.

**<Example>**

To find the sum of list L1:

Entry: sum (L1 )

Answer: 15

* It is also possible to sum values at specified locations.
In this case, the entry is sum (L1, 2, 5) to sum up 2nd trough 5th elements of L1.

[6 prod(] Used to multiply all terms in the list.

**<Example>**

To multiply all terms in list L1:

Entry: prod (L1)

Answer: 120

* For [6 prod ( ], it is also possible to multiply terms at the specified locations in the same manner as described in [5 sum ( ].

[7 stdDv ( ] Used to calculate the standard deviation of the list.

**<Example>**

To calculate the standard deviation of list L2:

Entry: stdDv (L2)

Answer: 3.214550254

[8 varian ( ] Used to calculate the variance of the list.

**<Example>**

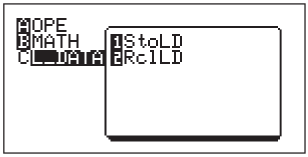
To calculate the variance of list L2:

Entry: varian (L2)

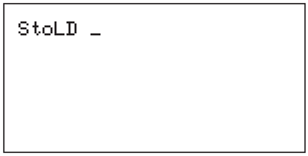
Answer: 10.33333333

## (3) L_DATA

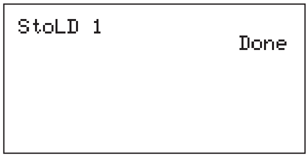
As previously described, up to six lists, L1 to L6, can be registered.
It is also possible to store all of the six lists and call them up as one list data.
List data is stored in up to 10 memory spaces, L_Data 1 to L_Data 9, and L_Data 0.
If this function is used efficiently, up to 60 lists (6 × 10) may be stored.
This menu allows you to store and call up the list data.




[1 StoLD] Used to store the list as list data.
On the [C L_Data] selection screen:
Press (1) to select StoLD. The screen shown to the right will appear.



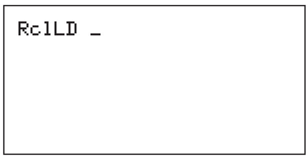

Press 1 (ENTER) to store the created list into L_Data 1.
If you wish to store the list into L_Data 2, press 2 instead of 1.



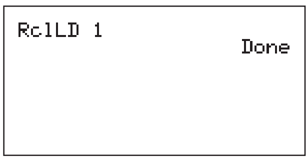

The message, “Done”, showing the completion of data storage, will appear on the screen.

[2 RclLD] Used to call up the stored list data.
The current list data is overwritten by called up list data.
On the [C L_Data] selection screen:

- Press (2) to select [RclLD]. The screen shown to the right will appear.




- Press 1 (ENTER) to call up list data 1.
The message, “Done”, showing the completion of data calling, will appear on the screen.



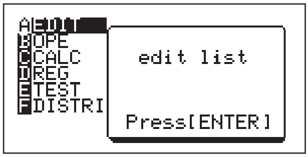
# 4. Editing and Easy Input of List Data

- The procedures previously described are used to edit and input list data. However, complex key operations are required to input and edit a great amount of data.
- This problem obviously occurs when inputting a lot of data, such as statistics data. In this case, the list function is commonly used because statistical data is handled as a list.
- To solve this problem, it is possible to directly input and edit the data to/from the list table.
- The list table is included in the statistics menu. Operations are explained in the following.

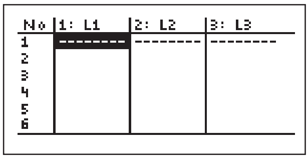
## (1) Inputting and editing the data using the list table

**Input:**

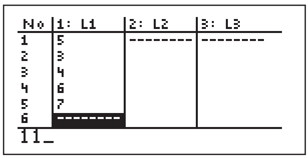
1. Press STAT.
2. The screen shown to the right will appear. Press ENTER.




3. Lists L1 to L3 will appear, each of which contains elements No. 1 to 6.
   In the initial state, all elements are blank and the cursor pointer is located at L1 - 1 (top line).

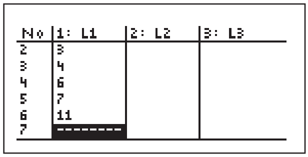



4. Input a numeric value and press ENTER. Numeric values can be input to elements of L1 in sequential order. It is also possible to input a numeric value, equation (for example “3 + 5”), and data in an independent memory space.
5. Input data (5, 3, 4, 6, 7, 11).
   Key operations: 5 ENTER 3 ENTER 4 ENTER 6 ENTER 7 ENTER 11.
   The data is input as shown to the right.




* The display on the bottom line is related to the cell where the cursor pointer is located. If any input data exists in the cell, its value is displayed. However, the maximum 10-digit value is displayed on the bottom of the screen, while the maximum 8-digit value excluding exponents is displayed in the cell.

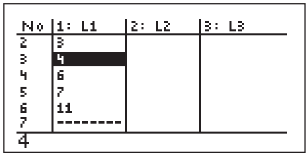
6. Press ENTER to scroll the data input screen. Item number 7 will appear on the screen.



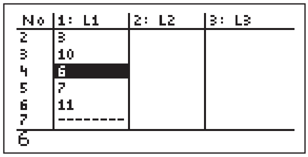

**Edit :**

Change data from “4” to “10” in the above example.

1. On the final input screen in the above example, press ▲ ▲ ▲ ▲ to move the cursor pointer to [4].
   It is also possible to move the cursor pointer by touching the cell where 4 exists with the touch-pen.




2. Press 10 ENTER to change the data from “4” to “10”.

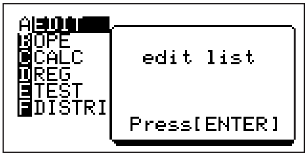


# CHAPTER 7 STATISTICS/ REGRESSION CALCULATIONS

- It is possible to find standard deviations and means for statistical data in 1-variable or 2-variable form.
- Other functions such as statistical data graphing, regression curve plotting, statistical tests and estimation calculation are also available.
- It is also possible to obtain coefficients for calculated regressions.
- This chapter explains the input procedure and calculation method of statistics and how to obtain regression curves.

# 1. Statistics

## (1) Calculating statistics




The function for statistical calculations can be displayed by pressing STAT (as shown on the right).

The outline of the menu is as follows:

[A EDIT] ..... Used to set the edit mode of the data.
(new data entry is initiated here).
[B OPE]...... Calculation menu to control items within the data.
[C CALC] ... Menu to obtain various statistics.
[D REG] ..... Menu to select and draw regression curves.
[E TEST] .... Statistical authorization menu
[F DISTRI].. Distribution

## (2) Statistics

- It is possible to input statistical data directly into the list.
- The amount of data allowed for input varies according to the used memory space, however, up to 999 elements can be entered (per list).
- Statistics obtained from entered statistical data are as follows:

**Statistics of 1-variable (x):**

n: sample number

$\bar{x}$: mean of sample (x)

sx: standard deviation of sample (x) (standard deviation when modulus is “n-1”)

$$sx = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n-1}}$$

σx: population standard deviation of sample (x) (standard deviation when modulus is n)

$$\sigma x = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n}}$$

Σx: sum of sample (x)

$\Sigma x^2$: sum of squares of sample (x)

xmin: smallest value of sample (x)

$Q_1$: median of Med and the smallest value

Med: median of sample (x)

$Q_3$: median of Med and the largest value

xmax: largest value of sample (x)

**Statistics of 2-variable (x, y):**

The following statistics are obtained in addition to the statistics of the 1-variable (x).

Σxy: sum of product of sample (x,y)

$\bar{y}$: mean of sample (y)

sy: standard deviation of sample (y) (standard deviation when modulus is (n-1))

σy: population standard deviation of sample (y) (standard deviation when modulus is n)

Σy: sum of sample (y)

$\Sigma y^2$: sum of square of sample (y)

ymin: smallest value of sample (y)

ymax: largest value of sample (y)

- These statistics are obtained by [1_Stats] or [2_Stats] of STAT C 1 or 2 after inputting statistical data.

## (3) Entering statistical data

- The calculator has six lists (L1 to L6) for entry.
- It is possible to combine the six lists into one list and save up to ten lists (L_Data1 to L_Data9 and L_Data0) separately (see CHAPTER 6 on page 145 for details).
- Try entering statistical data using examples below.
  (Here, we will solve by using [STAT] [C CALC])

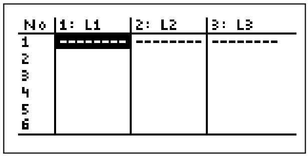
**<Example1>**

The following are test results of math and physics exams for ten students. The data for the math tests are entered in list 1 (L1) and the data for the physics tests are entered in list 2 (L2).

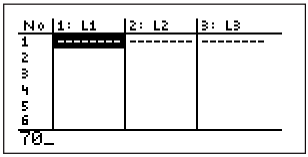
| Student | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Math (L1) | 70 | 83 | 91 | 68 | 65 | 72 | 56 | 78 | 95 | 73 |
| Physics (L2) | 65 | 80 | 78 | 80 | 90 | 86 | 70 | 62 | 88 | 68 |

* See CHAPTER 6 on page 155 for the input procedure.

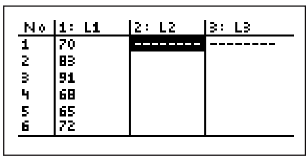
1. Display list by entering [STAT] [A] [ENTER].
   The cursor pointer will be displayed at the top of the L1 data display.
   Data can be entered at the position of the cursor pointer.



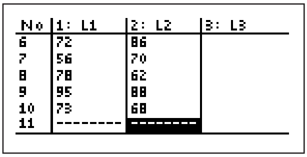

2. Input 70. We will first enter the score of the math test of student A.
   70 will be displayed at the very bottom as shown on the right. To complete entry [ENTER] must be pressed.
   * The picture on the right shows the state before pressing [ENTER]. It is possible to correct the “0” by using [◄] to move the cursor pointer (the very bottom) to “7Ø ”.




3. Press [ENTER] to input 70 to the first row of list L1.
   The cursor pointer will move to the second row.
   Continue entry for the remainder of list L1 data.
4. 83 [ENTER] 91 [ENTER] 68 [ENTER] 65 [ENTER] 72 [ENTER] 56 [ENTER] 78 [ENTER] 95 [ENTER] 73 [ENTER]
5. Use [►] to move the cursor to the top line of L2.



6. Enter the test results of the physics exam to L2 following the same procedure previously described.
   65 ENTER 80 ENTER 78 ENTER 80 ENTER 90 ENTER
   86 ENTER 70 ENTER 62 ENTER 88 ENTER 68 ENTER
   Now data entry is complete.




**Alternative entry procedure - Frequency table (using a weight list)**

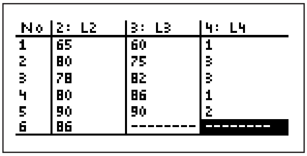
In the previous example, scores of the mathematics and physics tests are sequentially input into the lists L1 and L2, respectively. If the same data is duplicated, it is also possible to separately input the data values and their quantities.
For example, consider the points of the chemistry test shown in the following table.

| Student | A | B | C | D | E | F | G | H | I | J |
|---|---|---|---|---|---|---|---|---|---|---|
| Chemistry | 75 | 86 | 90 | 82 | 60 | 75 | 82 | 90 | 75 | 82 |

The table below shows the results after the above table is classified by points.

| Points | 60 | 75 | 82 | 86 | 90 |
|---|---|---|---|---|---|
| Number of students | 1 | 3 | 3 | 1 | 2 |

In the same manner as described previously, when inputting points to the list L3 and number of students to the list L4, the list shown to the right is obtained.
At this time, the list L4 is called weight list (Freq.) of the list L3. L3 and L4 are handled together as statistical data. The weight list is used to draw the statistical graph or calculate the statistical verification calculation described later. If no weight lists exist, the specification of a list name is unnecessary.



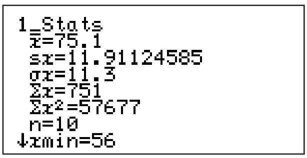

## (4) Calculating statistics (CALC menu)

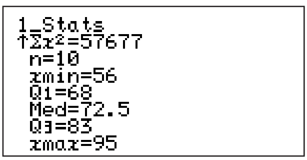
- Various statistics can be obtained by entering statistical data and using the CALC menu.
- The CALC menu can be selected by STAT C.

**<Example 2>**

Calculate one-variable statistics for the data in L1.

1. Press 2ndF QUIT STAT to display the statistics mode.
2. Press C 1 to transfer [1_Stats] to the standard function calculation screen.
3. First the statistics for L1 are obtained.
   Press 2ndF L1.
4. Press ENTER to display results.
5. Press ▼ ▼ ▼ ▼… to display all statistics.



6. Press [2ndF] [ENTRY] [◄] [DEL] [2ndF] [L2] [ENTER] to display results of the statistics for L2.
7. Press [▼] [▼] [▼] [▼]… to display all statistics.

```
1_Stats
 x̄=76.7
 sx=9.933668898
 σx=9.423905772
 Σx=767
 Σx²=59717
 n=10
↓xmin=62
```

```
1_Stats
↑Σx²=59717
 n=10
 xmin=62
 Q1=68
 Med=79
 Q3=86
 xmax=90
```

- Input “1_Stats list name” when obtaining statistics for only one variable. ([STAT] [C] [1])

- When obtaining statistics for two variables and the data list used for calculating statistics are L1 and L2, separate the list names by using “,” such as “2_Stats L1, L2”. ([STAT] [C] [2])

  Try executing 2_Stats using the data from example 1.

  Key operation:

  [STAT] [C] [2] [2ndF] [L1] [,] [2ndF] [L2] [ENTER]

  The results shown on the right are returned (use [▼] [▼]… to view the screens below).

```
2_Stats
 x̄=75.1
 sx=11.91124585
 σx=11.3
 Σx=751
 Σx²=57677
 n=10
↓xmin=56
```

```
2_Stats
↑xmax=95
 ȳ=76.7
 sy=9.933668898
 σy=9.423905772
 Σy=767
 Σy²=59717
↓Σxy=57850
```

```
2_Stats
↑sy=9.933668898
 σy=9.423905772
 Σy=767
 Σy²=59717
 Σxy=57850
 ymin=62
 ymax=90
```

## ANOVA(:

- This function is accessed using [STAT] [C CALC] [3].
- ANOVA executes single analysis of the quadratic deviation that compares the population mean of a population of two to a population of six.

  Statistical data is entered using list format.

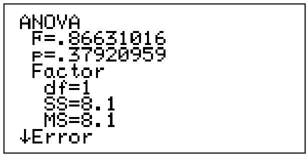
```
ANOVA(_
```

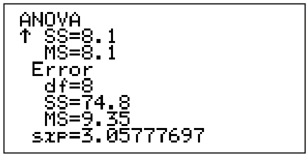
**<Example>**

Calculate using statistic lists L1:{30, 25, 28, 35, 31} and L2:{28, 25, 27, 29, 31}

```
ANOVA(L1,L2)_
```

- Press [⊞] [CL] [STAT] [C] [3] to transfer the function to the standard function calculation screen .
- Press [2ndF] [L1] [ , ] [2ndF] [L2] [ ) ] to input the data list.
- Press [ENTER] and the answer shown to the right will appear.
- The answer is shown using two screens.




* F, p, df, SS, MS and sxp indicate statistic, probability, degree of freedom, sum of squares, quadratic mean, and standard mean, respectively.

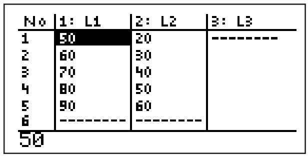
## (5) Editing statistical data

- To edit already input statistical data, enter the EDIT mode of the stat menu, as with standard input.

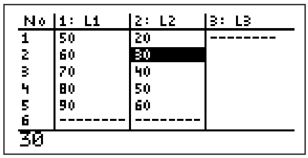
### To change one data entry at a time:

**<Example 3>**

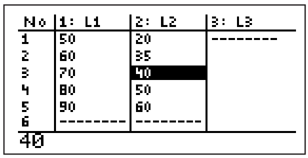
There is a list of statistical data such as the one shown on the right. We will change the “30” located on the second row of L2 to “35”.




1. Move the cursor pointer to “30” by pressing [▶] [▼].




2. Press 35 [ENTER] to change the content.




### To delete one data entry:

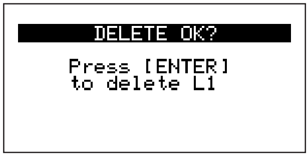
- Move the cursor pointer to the location for deletion and press [DEL]. The data is deleted and the rows below will move upwards by one row.

### To delete one list:

- Use the OPTION menu (See CHAPTER 13 on page 260.)

1. Move the cursor pointer to the list name to delete using [2ndF] [OPTION] [C] [1]
2. Press [ENTER] to delete all data within the list selected.

- To delete a list from the list screen, use [▲] [▼] to move the cursor pointer from the data display to the list names (L1 to L6).
  The screen shown on the right will appear when pressing [DEL] (when list L1 is selected).
  Press [ENTER] to delete all data from the selected list.
  The list is now blank.
  Press any other key except [ENTER] to return to the previous list display screen.



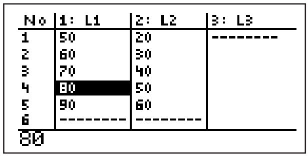

### Inserting data:

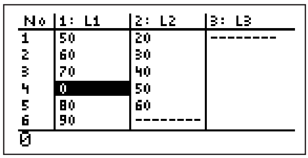
If data is found missing after completing input, it is possible to open a specific location and insert data.

**<Example 4>**

Insert “40” between rows 3 and 4 of list L1 of example 3.

1. Use [◄] [►] [▲] [▼] to move the cursor pointer to the row below the location of insertion (in this case, move the cursor pointer to row 4 of L1 : “80”)
2. “0” is displayed when pressing [2ndF] [INS] and displayed items below the cursor are shifted one row down.
3. Press 40 [ENTER]. “40” will be entered in the row 4 and number of data for L1 will be 6.

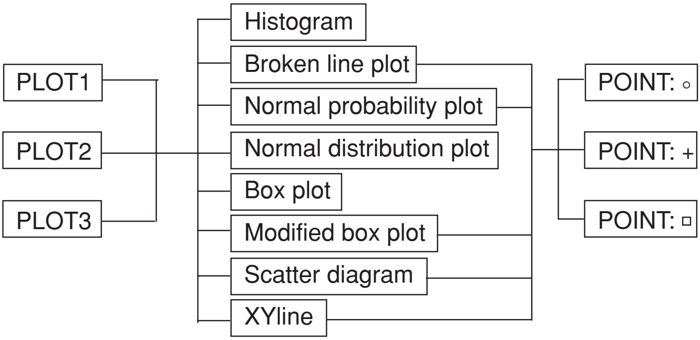



## (6) Graphing statistical data

- It is possible to display the obtained statistical data as graphs to check the state of distribution.
- 3 types of graphs can be drawn using the same statistic list.
- For statistical graphs the user may choose among histogram, broken line plot, normal probability plot, normal distribution plot, box plot, modified box plot, scatter diagram, and XY line.
  It is also possible to select 3 types of dots for each broken line plot, normal probability plot, modified box plot, scatter diagram, and XYline plotted.

The following is a list of statistical graph types available on the calculator.

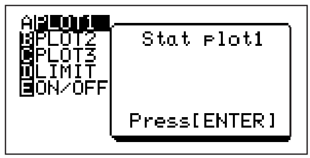


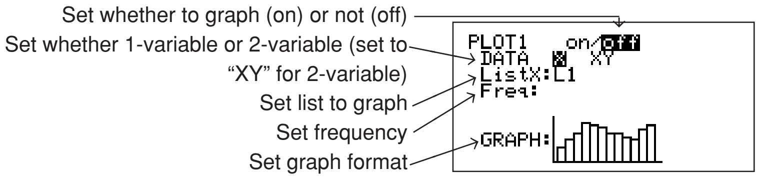

- For example, it is possible for PLOT 1  to be a Broken line plot using (+) as plotting dots and PLOT 2 to be a Histgram.

**<Example 5>**

Here, we will take the data from example 1. A histogram will be made using the scores for the math tests as PLOT 1. A broken line plot (plot: □) will be made using the physics scores as PLOT 2. First, we will set a graph using the math scores (L1).

1. Press (2ndF) (STATPLOT).
2. Specify PLOT1 by pressing (A) (ENTER) and the screen will change as shown below.

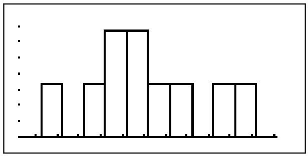



- This screen shows that PLOT1 is off (graphing invalid) and is a 1-variable and that a histogram of list 1 is selected. Press (ENTER) to select "on".
- In this screen, the highlighted location, as well as the displayed list name and graph image diagram are selected.
- The cursor is positioned at the very top where "on" is displayed when first opening the screen (flashing display).

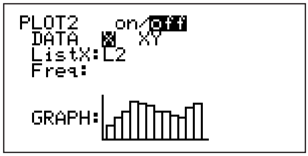
* To clear the contents entered in "Freq", move the cursor to the list name then press (DEL) (ENTER).

3. Press GRAPH ZOOM [A ZOOM] [9 Stat]. The graph shown on the right will appear.

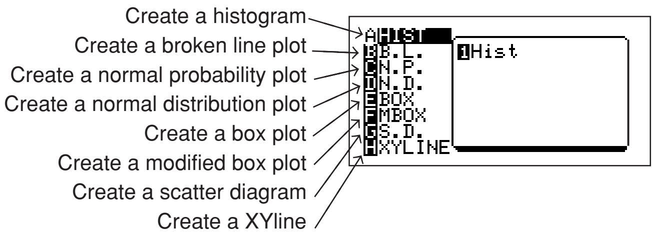


Next, we will set the graph for the physics scores (L2).

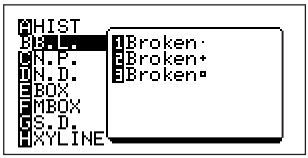
4. Press 2ndF STATPLOT.
5. Press B ENTER to display the same type setting screen as above. The only difference is that PLOT2 will be displayed on the top left corner of the screen.
6. Press ENTER.
   "on" will be highlighted.



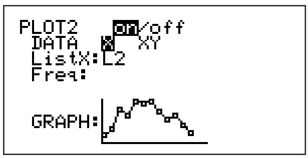

7. Press ▼ ▼ to move the cursor pointer to "List X: L1".
8. Press 2ndF L2 ENTER to change to "List X: L2".
9. Press ▼ to move the cursor pointer to "GRAPH".
10. Press 2ndF STATPLOT to display the graph type selection screen shown below.




11. Press B to select the broken line plot.
    [1 Broken•] displays points using "•", [2 Broken+] displays points using "+" and [3 Broken▫ ] displays points using "▫".




12. Press 3 to return to the previous screen.
    At this time, the graph image diagram located at the bottom of the screen is changed.
13. Press GRAPH to graph the contents of list L2 using the specified format.

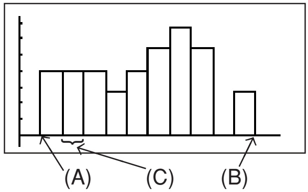



• "Freq" on the screen indicates the space where frequency is entered. The frequency list is entered in this space when data and the frequency for the data are entered as a list, etc. at the time of creating a statistical data list.

## (7) Explanation of graph types

- As mentioned earlier, the calculator is capable of drawing 8 types of graphs using statistical data.
- Graphs are selected by pressing 2ndF STATPLOT again in the STAT PLOT mode.
- Overviews of each graph are given below.

### Histogram (A HIST):




- A bar graph is drawn using the entered statistical data (x).
- The X-axis shows the difference between MAX and MIN values of the statistical data divided evenly by 10.
- The Y-axis shows the frequency.

  (A): shows the smallest value (Xmin) of the statistical data.

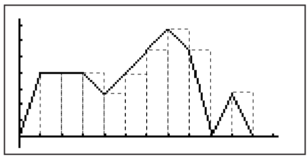
  (B): shows the largest value (Xmax) of the statistical data.

  (C): The number of divisions is shown as the equation $\left(\frac{\text{Xmax}-\text{Xmin}}{\text{Xscl}}\right)$.

  * The above screen will appear when pressing ZOOM [A ZOOM][9 Stat] and setting the WINDOW VALUE to automatic.

  * The number of divisions for the above equation can be set using a number in the range of 1 through 64. Change the windows setting in order to change the number of division. (See CHAPTER 4, “11. Setting a Window” on page 104.)

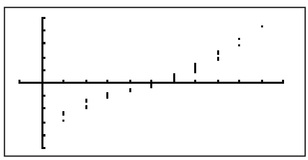
### Broken line plot (B B.L.):



- Displays the frequency distribution of entered statistical data (x) using a broken line.
- The correlation of points between a histogram and a broken line plot is as shown on the right (The broken line is displayed by connecting the upper left points of the bars of the histogram. In other words, the class width of a histogram is represented by the upper left point of the bar graph.)

  * It is possible to draw both a histogram and a broken line plot on a screen at the same time. In this case, the histogram is not displayed with dots as shown in the diagram above. This diagram uses a dotted line as a convenience to show the relationship between a histogram and a broken line plot.
- Three types of points may be selected: “•”, “+” or “▫”.

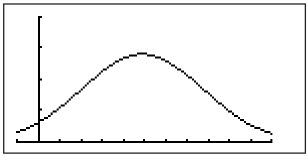
### Normal probability plot (C N.P.):



- Statistical data (x) on the horizontal axis displays the variable of the normal distribution that is standard for that data. .
- If the dots are plotted in a near-straight line, it indicates that the data is normal.
- The division number is shown using a equation identical to that of a histogram.

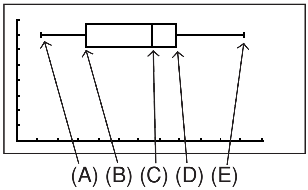
- **Data for the Normal Probability Plot:**
  It is not possible to set the frequency in the Normal Probability Plot (NP.P.) of the statistical graphs. The statistical data should be created using only one list instead of splitting the statistical data into the data and frequency.

## Normal distribution plot (D N.D.):



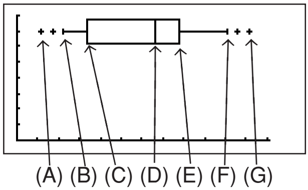
- Draws the normal distribution curve of entered statistical data (x).
- Horizontal axis (x) are data in the range of Xmin to Xmax.

## Box plot (E BOX):



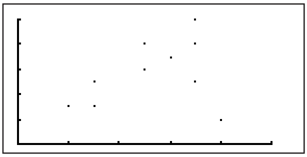

- Shows the entered statistical data (x) using box plot.
- Definitions of points on the graph are as follows:
  (A): Smallest value (Xmin) of the statistical data.
  (B): Median (Q1) between the median (Med) and the smallest value (Xmin) of the statistical data.
  (C): Shows the median (Med) of the statistical data.
  (D): Shows the median (Q3) between the largest value (Xmax) and the median (Med) of the statistical data.
  (E): Shows the largest value (Xmax) of the statistical data.

## Modified box plot (F MBOX):



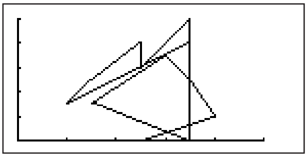

- Shows the entered data (x) using modified box plot.
- Definition of points on the graph are as follows:
  (A): Shows the smallest value (Xmin) of the statistical data.
  (B): Shows the tip of the extension and is defined by "(Q3–Q1)×1.5".
  (C): Shows Q1 (same as for box plot).
  (D): Shows Med (same as for box plot).
  (E): Shows Q3 (same as for box plot).
  (F): Shows the tip of the extension and is defined by "(Q3–Q1)×1.5".
  (G): Shows the maximum value (Xmax) of the statistical data.
- The length of the extension from the box is determined by Q1 and Q3.
- Statistical data on the outside of the extension are shown using dots.
- 3 types of dots can be used: "•", "+" and "▫".

### Scatter diagram (G S.D.):



- When statistical data (X) and (Y) are entered, the (Y) value with respect to the (X) value is drawn.
- 2-variable statistical data is required for drawing a scatter diagram.
- There are three types of points: "•", "+" and "▫".
- Statistical data lists can be set freely to either the X or Y axis.

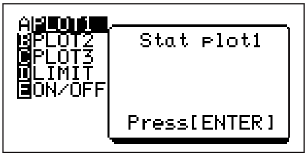
### XYLine (H XYLINE):



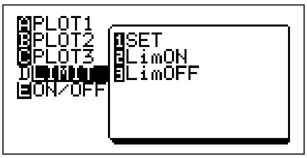
- Displays a graph that connects each point of a scatter diagram.
- Each point is connected in the sequence (sequence of rows) of the statistical data.

## (8) Specifying statistical graph and graph functions

- As mentioned earlier up to three graphs can be drawn per one statistical data.
- Press [2ndF] [STATPLOT] to specify statistical graphing.
- Select one from [A PLOT1] to [C PLOT3] to advance to the detailed setting screen of each graph.




- It is possible to overlap graphs PLOT1 to PLOT3 when displaying.
  When overlapping graphs, graphings of PLOT1 to PLOT3 are all valid.
- It is possible to display and delete graphs by setting graph on/off for each graph.
- LIMIT settings
  Press [D LIMIT] and the display shown to the right will appear.



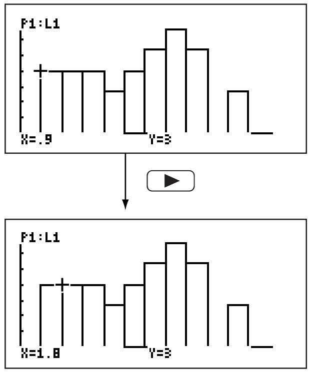

  Use [D LIMIT] to set the upper and lower limit lines to display on a statistical graph. It is also possible to select whether to display lines indicating upper and lower limits, as well as the line indicating the mean of x [2 LimON] or not [3 LimOFF].
  For upper and lower limit lines, input the upper and lower limit values for plotting after selecting [1 SET].
  Upper and lower limit lines are displayed using short broken lines. The mean is indicated using a long broken line.

## (9) Trace function of statistical graphs

- As with function graphs, statistical graphs are also equipped with a trace function to move the cursor pointer on graph curves.
- To operate this function, press TRACE then use ◄ ► to move the cursor pointer once it appears on-screen.
- The location of where the cursor pointer appears and the amount it moves are different for some statistical graphs. This is explained below.

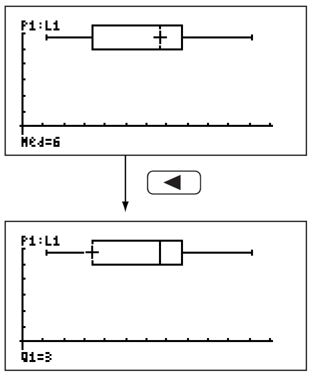
### Cursor pointer in histograms:

- For histograms, the cursor pointer appears on the very left side when pressing TRACE.
- When using ► to trace a histogram, the cursor pointer moves from the top left of each bar to the next in sequence.
- The bottom of the screen displays X and Y value.

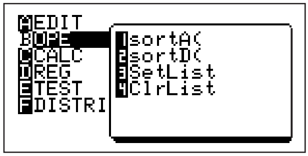



### Box plots, modified box plots:

- The cursor pointer appears in the Med value when the TRACE is pressed.
- The cursor pointer can be moved using ◄ ►. However, it moves in units of Q1, Q3, min, max, etc.
- The bottom of the screen displays the name of the location where the cursor pointer is currently located.



## (10) Data list operation function (B OPE)




(initial screen)

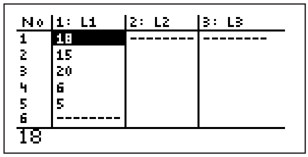
- Press STAT B to display the screen shown on the right.
- Within the OPE menu are four functions to process data lists.

**[1 sortA( ]**: organizes list contents in ascending order.

- This function operates in the same manner as "sort A(" of 2ndF LIST A 1. See page 149 for details.
- Here, we will explain how the list contents are organized.

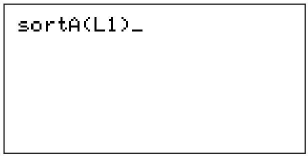
**<Example 6>**

18, 15, 20, 6, 5 have been entered to list L1 as statistical data.

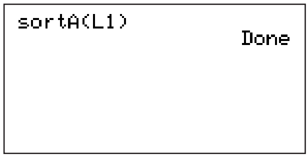



We will now organize this data list in ascending order.

1. Press STAT B 1 to display "sortA(" on the screen.
2. Press 2ndF L1 ) to specify list (L1).




3. The contents of L1 will be organized when pressing ENTER.




**[2 sortD( ]**: organizes list contents in descending order.

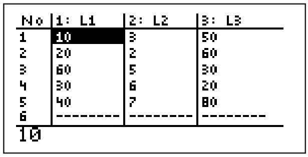
- This function operates in the same manner as "sort D(" of 2ndF LIST A 2. See page 149 for details.
- Operation procedure is the same as for "sort A(". "sortD(" can be selected by specifying B 2 when selecting from the menu.

**[3 SetList]**: organizes the lists in the specified order.

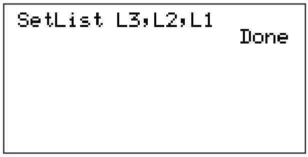
- Entry: SetList list name, list name,…
- Up to 6 list names can be specified. List names must be separated using [ , ].
- Entered list names are arranged in order from the left.
- When entering only one list name, that list will be displayed on the very left.

**<Example 7>**

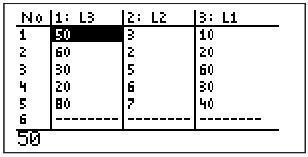
There are lists L1 to L3 with statistical data shown on the right. We will arrange the list in the order of L3, L2, and L1.




1. Press [STAT] [B] [3] to specify SetList.
2. Input list names in the order to be arranged by pressing [2ndF] [L3] [ , ] [2ndF] [L2] [ , ] [2ndF] [L1].
3. Press [ENTER] to execute arrangement.

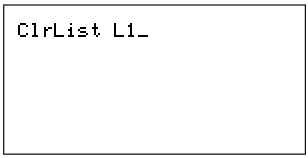



4. Press [STAT] [A] [ENTER] to check contents.




**[4 ClrList]**: deletes all data of specified lists.

- Entry: ClrList list name, list name, list name,…
- Up to 6 list names can be entered. List names must be separated using “,”.
- For example, to delete data of list L1, enter as shown on the right.

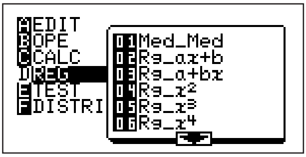


# 2. Regression

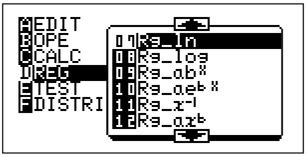
- Regression curves are selected from the [D REG] menu in the statistic mode.
- Check the menu contents.

  Press [STAT] [D] to display the primary screen of the REG menu. There are two other screens that can be accessed by moving the cursor pointer to the submenu side (the right half of the screen displaying "01 Med_Med", etc.) and pressing [ALPHA] [▼] [ALPHA] [▼].

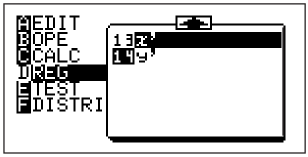
Primary screen




Secondary screen

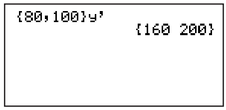



Third screen




| Function name | Description | Regression formula | Parameter |
|---|---|---|---|
| 01 Med_Med | Finds the regression curve using the median-median method. | y=ax+b | a,b |
| 02 Rg_ax+b | Finds the regression curve using the linear equation (linear regression-1). | y=ax+b | a, b, r, $r^2$ |
| 03 Rg_a+bx | Finds the regression curve using the linear equation (linear regression-2). | y=a+bx | a, b, r, $r^2$ |
| 04 Rg_$x^2$ | Finds the regression curve using the second degree polynomial (quadratic regression). | $y=ax^2+bx+c$ | a, b, c, $R^2$ |
| 05 Rg_$x^3$ | Finds the regression curve using the third degree polynomial (cubic regression). | $y=ax^3+bx^2+cx+d$ | a, b, c, d, $R^2$ |
| 06 Rg_$x^4$ | Finds the regression curve using the fourth degree polynomial (quartic regression). | $y=ax^4+bx^3+cx^2+dx+e$ | a, b, c, d, e, $R^2$ |

| Function name | Description | Regression formula | Parameter |
|---|---|---|---|
| 07 Rg_In | Finds the regression curve using the natural logarithm formula (natural logarithm regression). | $y=a+b\ln x$ | a, b, r, $r^2$ |
| 08 Rg_log | Finds the regression curve using the common logarithm formula (common logarithm regression). | $y=a+b\log x$ | a, b, r, $r^2$ |
| 09 Rg_ab$^x$ | Finds the regression curve using the exponential function formula (exponential regression-1). | $y=ab^x$ | a, b, r, $r^2$ |
| 10 Rg_ae$^{bx}$ | Finds the regression curve using the exponential function formula (exponential regression-2). | $y=ae^{bx}$ | a, b, r, $r^2$ |
| 11 Rg_x$^{-1}$ | Finds the regression curve using the inverse function formula (reciprocal regression). | $y=a+bx^{-1}$ | a, b, r, $r^2$ |
| 12 Rg_ax$^b$ | Finds the regression curve using the power function formula (power regression). | $y=ax^b$ | a, b, r, $r^2$ |
| 13 Rg_logistic | Finds the regression curve using the logistic logarithm formula (logistic regression). | $y=c/(1+ae^{-bx})$ | a, b, c |
| 14 Rg_sin | Finds the regression curve using the sin regression formula.<br>The calculator will fit a sin curve for unequal, as well as equal, spacing. | $y=a\bullet\sin(bx+c)+d$ | a, b, c, d |

<table>
<tr><th>Function name</th><th>Description</th><th>Regression formula</th><th>Parameter</th></tr>
<tr><td>15 X’</td><td colspan="3">Find the estimated value of X when a value Y was given by complying to the function found using the regression formula.<br>Entry: AX’ (numerical values or list are entered in A. Multiple solutions can be obtained at the same time of inputting list.)<br><Example 8> when the following is entered as statistical data.<br><table><tr><td>X</td><td>10</td><td>20</td><td>30</td><td>40</td><td>50</td></tr><tr><td>Y</td><td>20</td><td>40</td><td>60</td><td>80</td><td>100</td></tr></table>Find estimated value of x given “y=140”.<br>Key operation: [+−×÷] 140 [STAT] [D] [1] [5] [ENTER]<br><br></td></tr>
<tr><td>16 Y’</td><td colspan="3">Find the estimated value of Y when a value X was given by complying to the function found using the regression formula.<br>Entry: AY’ (numerical values or list are entered in A. Multiple solutions can be obtained at the same time of inputting list.)<br><Example 9> Data from example 8 are entered. Here we will find the estimated value for Y given “X= 80, 100”.<br>Key operation: [+−×÷] [2ndF] [{] 80 [,] 100 [2ndF] [}] [STAT] [D] [1] [6] [ENTER]<br><br></td></tr>
</table>

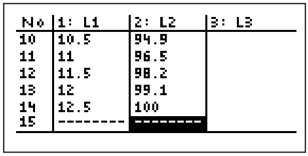
- X', Y' will be valid after regression calculations, excluding 2nd, 3rd and 4th degree polynomial regressions, logistic regression and sin regression, have been done.

**<Example10>**

The following relationship was found when heating a beaker filled with water.
Find the regression equation using the data and estimate the water temperature before heating.

| Time (sec) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 10.5 | 11 | 11.5 | 12 | 12.5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Water temperature (°C) | 38.4 | 46.4 | 54.4 | 62.5 | 69.6 | 76.1 | 82.4 | 88.6 | 93.4 | 94.9 | 96.5 | 98.2 | 99.1 | 100 |

1. Press [STAT] [A] [ENTER] to display the list input screen.

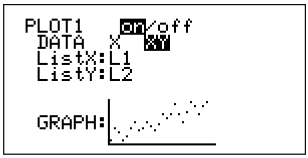



First, we will enter the time in list L1 and the water temperature in list L2.

2. Complete time entry by pressing 2[ENTER] 3[ENTER] 4[ENTER] …12.5[ENTER] [▶].
3. Complete water temperature entry by pressing 38.4[ENTER] 46.4[ENTER] 54.4[ENTER] …100 [ENTER].

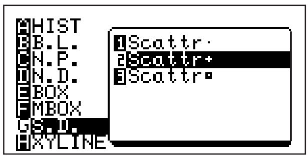
Next, we will set the statistical graph settings and plotting location.
Here, PLOT1 is displayed using a scatter diagram.

4. Specify PLOT1 by pressing [2ndF] [STATPLOT] [A] [ENTER].
5. Press [ENTER] to turn on PLOT.
6. Specify 2-variable "XY" by pressing [▼] [▶] [ENTER]. "ListY" (Y axis) is displayed in the list and L2 is automatically displayed.

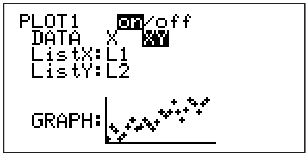



Next, we will specify "+" as the graph dot type used.

7. Press [2ndF] [STATPLOT] [G] [2] to specify graph type, scatter diagram and dot type: "+". The GRAPH image screen dot will change to "+", indicating that "+" has been specified as the dot type.



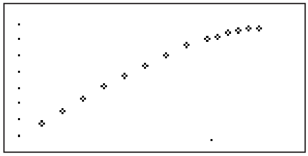
8. Press [ZOOM] [A] [9] to draw the scatter diagram of this statistical data.



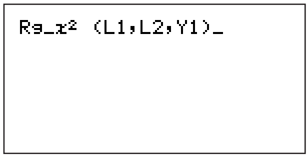

* Selecting [A] [9] in the ZOOM mode allows for quick graphing in an optimum range since window setting values of the graph plotting screen are automatically set using the Window set list data.

* Graphs can be drawn using [GRAPH] ; however, since the current window setting values are used for the statistical graph, the desired graph may not always be displayed.
In this case, it is necessary to reset the screen range by pressing [WINDOW].

- Next, we will draw a regression curve.



- Since water temperature will not rise above 100°C under normal pressure, the regression formula for the curve up to 100°C point is solved.
- It seems appropriate to decide whether it is a exponential regression or quadratic regression.
  Here, we will draw a regression curve using the quadratic regression.



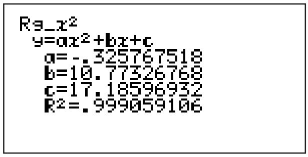

9. Press [⊞] [CL] [STAT] [D] [0] [4] to display "Rg_$x^2$" on-screen.
10. Press [(] [2ndF] [L1] [,] [2ndF] [L2] [,] [VARS] [A] [ENTER] [A] [1] [)]

Specify objective list number (for [(] [2ndF] [L1] [,] [2ndF] [L2] [,])

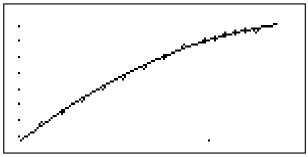
Specify Y1 (for [VARS] [A] [ENTER] [A] [1] [)])

* [VARS] is explained in a later section (see CHAPTER 12 "6. Other Functions Often Used in Programs" on page 251 for details)

- The reason for specifying Y1 here is to store the formula obtained by the regression calculation to Y1 (Formulas obtained using regression graphs cannot be displayed unless stored to either Y1 to Y9, and Y0).




11. Press ENTER to display the regression formula and parameters as shown on the right.
12. Press GRAPH to draw a regression curve using the found parameter values and the scatter diagram.



- A regression curve close to the estimated point was found.
- If there is a large difference between the regression curve and plotted dots of the statistical data, change the regression curve and repeat steps 9 through 12.

* If a formula already exists in the formula number for entering the regression formula, existing contents will be replaced by the new contents.

About the residual list

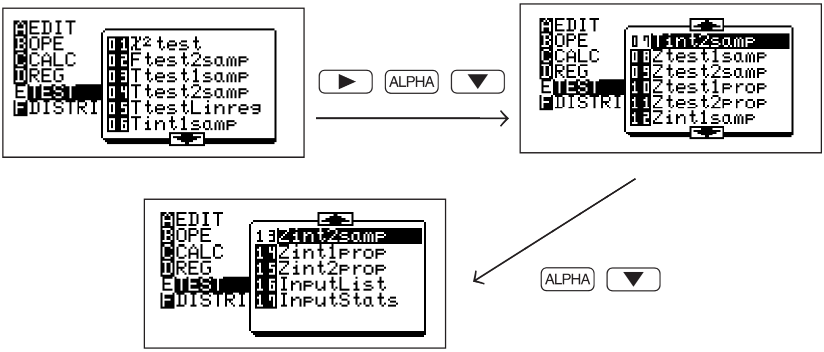
- There are residuals between regression curves and actual values.
- The residual list stores these residuals automatically.
- [resid] list can be found in [B REGEQN][0 resid] of the STAT VARS menu (VARS [H STAT]).
- Use the following key operation to recall the residual list from the standard function calculation screen.

  [+−×÷] CL VARS H ENTER B 0
- Press ENTER to display the residual list on-screen.
- To show the residual list in the form of a graph, first store as a list, then follow the graphing operation.

* [resid] cannot be graphed when specified independently.

# 3. Statistic Testing

- The calculator is equipped with a test function for statistical data.
- To use the statistic test function, press STAT then select “E TEST”.
- There are 17 options within the “E TEST” menu (check by pressing ▶ ALPHA ▼).
- All of the options used in statistical testing are shown below.




- To use a test function, select the most suitable function from the options and solve after inputting statistics of each specification in the EDIT screen.
- There are two types of input method for inputting statistics in the EDIT screen of a test function: input from a statistics data list and numerical value input (however, there are some test functions that cannot be input from a list (see below)).
- [16 InputList] and [17 InputStats] indicated above specify the input method of statistics.

[16 InputList] : Set input mode to the statistic data list method.
[17 InputStat] : Set input mode to the value input mode.

* Either list input or parameter input may be used for tests other than [01 $\chi^2$test], [05 TtestLinreg], [10 Ztest1prop], [11Ztest2prop], [14 Zint1prop] and [15 Zint2prop].
* To clear the contents entered in “Freq”, move the cursor to the list name then press DEL ENTER.

For example, to set to the numerical value input mode:
Press STAT E 1 7 ENTER
The screen shown to the right appears, indicating that the numerical value input mode has been set.

```
InputStats
                Done
```

- When setting to the statistics input method, all statistic test functions are valid.
  To change the setting, follow the previously described procedure to change modes.

**[01 $\chi^2$ test]**

Test $\chi^2$ using the sample data of a 2-way table represented by a matrix.

**<Example 1>**

As shown below, the sample data is in the form of a matrix and is stored to mat A. We will use this to test $\chi^2$ and store the result in mat B.

Note: Matrix data must be integers

$$\text{mat A} = \begin{vmatrix} 3 & 2 & 5 & 4 \\ 6 & 1 & 3 & 8 \\ 2 & 3 & 5 & 1 \end{vmatrix}$$

- Press STAT E 0 1 to input necessary items.
  Input matrix name with the sample data for testing in Observed Matrix. Input matrix name in which to insert test result in Expected Matrix.

```
χ²Test
 Observed Matrix:mat A
 Expected Matrix:mat B
```

- Since the cursor pointer is located at Observed Matrix, we will first input mat A.
- Press MATRIX A 1 ENTER to transfer mat A to the screen and move the cursor pointer down.
- Press MATRIX A 2 to input mat B.

```
χ²Test
 χ²=7.981584913
 p=.239455549
 df=6
```

Press 2ndF EXE to display the answer. The result will be the input to mat B in a matrix format.
Opening mat B will display the matrix shown to the right.

```
mat B :  3×4
       1        2        3
 1 [ 3.5814   1.95349  4.23256 ]
 2 [ 4.60465  2.51163  5.44186 ]
 3 [ 2.81395  1.53488  3.32558 ]
```

* $\chi^2$ indicates statistics

**[02 Ftest2samp]**

Two sample data collected from two different populations are tested for population standard deviation $\sigma_1$ and $\sigma_2$.

**<Example 2>**

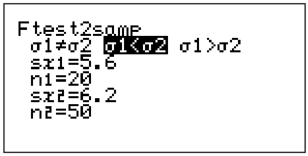
To test population standard deviation $\sigma_1 < \sigma_2$ for the two sample data, $n_1 = 20$, standard deviation $sx_1 = 5.6$ and $n_2 = 50$, standard deviation $sx_2 = 6.2$, follow the next steps.

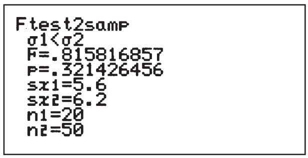
- Since we will use the numerical value input method of statistics values for this test, we will first set the unit to the numerical value input mode.

1. Press [+−×÷] [STAT] [E] [1] [7] [ENTER] to set the unit to the numerical value input mode.
2. Press [STAT] [E] [0] [2] to display the parameter input screen.
3. Press [▶] [ENTER] [▼] to highlight (select) "$\sigma_1 < \sigma_2$".
   (In the default setting, the cursor pointer will appear at "$\sigma_1 \neq \sigma_2$".)
4. 5.6 [ENTER] 20 [ENTER] 6.2 [ENTER] 50 [ENTER]
5. Press [2ndF] [EXE] to solve.

* F indicates statistics and P indicates probability.

* No input is necessary when there is no weight list.




**[03 Ttest1samp]**

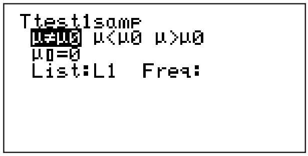
Tests the hypothesis of population mean μ when the population standard deviation "σ", from one sample data of a collected population, is unknown.

**<Example 3>**

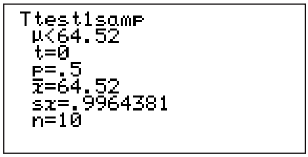
We will test the validity of the sample mean $\mu_0$, 64.52, obtained from statistical data {65.6, 62.8, 66.0, 64.5, 65.1, 65.3, 63.8, 64.2, 63.5, 64.4} of n=10 from a given population (solve by hypothesizing $\mu < \mu_0$).

1. We will use the list input method for the statistical data. Input statistics to list L1.
   (Press [STAT] [E] [1] [6] [ENTER] to set list input mode.)
   [STAT] [A] [ENTER] 65.6 [ENTER] 62.8 [ENTER] 66 [ENTER] 64.5 [ENTER] 65.1 [ENTER] 65.3 [ENTER] 63.8 [ENTER] 64.2 [ENTER] 63.5 [ENTER] 64.4 [ENTER]

* If the cursor pointer is not at L1, use the [◄][►] keys to move and clear previous data, then input data.




2. Press [STAT] [E] [0] [3] to display the parameter input screen (as shown to the right).
3. Press [►] [ENTER] [▼] to specify (highlight) "$\mu < \mu_0$" and move cursor pointer to $\mu_0$.
4. Input sample mean by entering 64.52 [ENTER].
5. Specify list L1 by pressing [2ndF] [L1] [ENTER].
6. Input list weight by pressing [ENTER] (when there is a weight list, input list name).
7. Press [2ndF] [EXE] to obtain the answer shown to the right.




* t indicates statistics, P indicates probability and sx indicates sample standard deviation.

* No input is necessary when there is no weight list.

**[04 Ttest2samp]**

Tests two sample means, $\mu_1$, $\mu_2$, when the population standard deviations, $\sigma_1$, $\sigma_2$, from two sample data collected from two different sources are unknown.

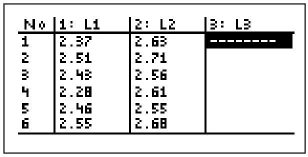
**<Example 4>**

Test "$\mu_1 \neq \mu_2$" in following two sample data:

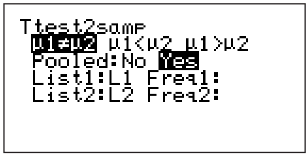
Data 1 …(2.37, 2.51, 2.43, 2.28, 2.46, 2.55, 2.49)

Data 2 …(2.63, 2.71, 2.56, 2.61, 2.55, 2.68, 2.42, 2.48, 2.51, 2.65)

The test will be conducted using the previous data.



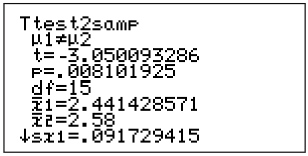

1. Set to the list input (InputList) mode
   Press STAT A ENTER to input data 1 to list 2 (L2) and data 2 to list 3 (L3).

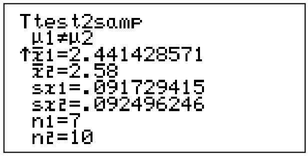



2. After inputting lists, press STAT E 0 4 to open the parameter input screen of “Ttest2samp”, then input each parameter and test method.

* When there is no Freq specification, calculation is executed with weight as “1”.

* Pooled is prediction for unknown $\sigma_1$, $\sigma_2$.
Select “No” if $\sigma_1$, $\sigma_2$ are subjectively unequal.
Select “Yes” if $\sigma_1$, $\sigma_2$ are equal.
Calculation is executed using this prediction as the basis.




3. Press 2ndF EXE to solve.
   The answer is shown using two screens.

* “df” indicates degree of freedom.

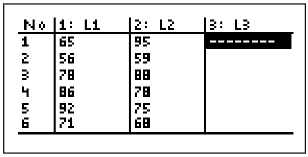
**[05 TtestLinreg]**

Tests the hypothesis of slope β of linear regression straight line “Y = α + βx” and correlation coefficient ρ of two dimensional sample data obtained from two different populations.

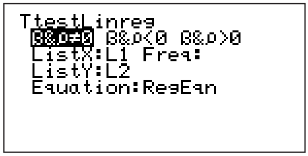
**<Example 5>**

The test is conducted under the assumption that the value of slope β and correlation coefficient ρ obtained from statistical data X (65, 56, 78, 86, 92, 71, 68) and Y (95, 59, 88, 78, 75, 68, 80) randomly extracted from two different populations are β & ρ ≠ 0.

1. Since we will be using lists to input statistics, press [STAT] [A] [ENTER] to display the list screen.



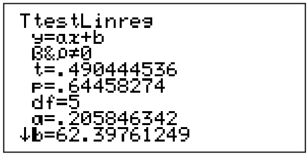

2. Input statistical data x to list 4 and y to list 5 (as shown to the right).
   (If other data exists in list 4 or 5, delete data or register under a different list name.)
3. Press [STAT] [E] [0] [5] to open the parameter input screen of TtestLinreq then input necessary items.



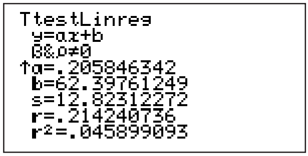

* It is not necessary to input equation items.

* If a linear (straight line) regression calculation has been executed using the above data and the function equation (Y1 to Y9, and Y0) has been stored, input that equation number.

4. Press [2ndF] [EXE] to solve
   The answer is given using two screens




* a,b indicates regression coefficients, s indicates standard error, r indicates the correlation coefficient and $r^2$ indicates the coefficient of determination.




**[06 Tint1samp]**

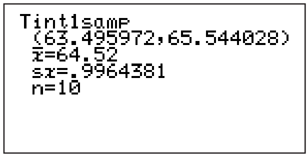
Finds the confidence bound of population mean μ when the value of population standard deviation σ from sample data of a population is unknown.

**<Example 6>**

Sample data from example 3 is used. We will use this to find the confidence bound of μ with level of confidence at 0.99.

1. Set to list input mode (InputList). The statistical data is assumed to be stored in L1.

2. Press STAT E 0 6 to input each parameter (as shown to the right).
3. Press 2ndF EXE to solve (as shown to the right).
   The numerical value within ( ) shows the confidence bound with level of confidence at 0.99.


* sx indicates sample standard deviation.
* When using the numerical value input mode, n is a positive integer.
* For the C-level, % input mode is accessed when the entered value is 1 to 100.

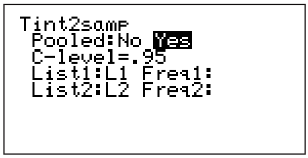
**[07 Tint2samp]**

Finds the confidence bound of the difference of two sample means, $\mu_1$ and $\mu_2$, when the population standard deviations, $\sigma_1$ and $\sigma_2$, from two sample data sets collected from two different populations, are unknown.

**<Example 7>**

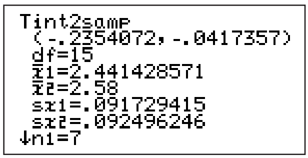
Here, we will find the confidence bound of $\mu$ with the level of confidence at 0.95 using the contents from example 4 (statistical data is assumed to be stored in L2 and L3).

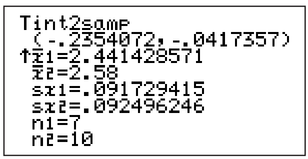
1. Set to list input mode (InputList).
2. Press STAT E 0 7 to input each parameter (as shown to the right).




3. Press 2ndF EXE to solve (as shown to the right).
   The answer is shown using two screens.
   The numerical value within () indicates the confidence bound of the differences between $\mu_1$ and $\mu_2$ when the level of confidence is 95%.

* When using the numerical value input mode, “n1”, “n2” are positive integers.



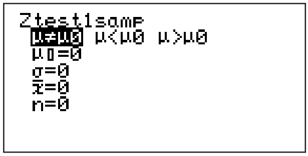
**[08 Ztest1samp]**

Tests the hypothesis of population mean μ when the value of the population standard deviation, σ, from sample data collected from a population, is known.

**<Example 8>**

The average weight and standard deviation (σ) for a product being manufactured are known to be 52.4g and 4.5, respectively.
The validity is judged when the weight of 20 of these units averages 53.4g (x).

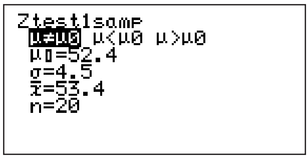
1. Since we will be using numerical input for entering the statistics, set to the numerical value input mode.
   STAT E 1 7 ENTER
2. Select Z test from the statistic function menu then input each parameter.
   Press STAT E 0 8 to display the Ztest parameter input screen (as shown to the right).



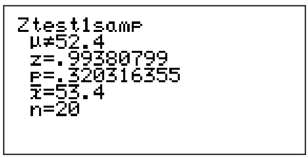

## Explanation of the screen:

- $\mu \neq \mu_0$, $\mu < \mu_0$, $\mu > \mu_0$…Hypothesis setting (double side test, single side test settings)
- μ indicates the population mean, $\mu_0$ indicates the population mean hypothesis obtained from sample data, σ indicates the population standard deviation, $\bar{x}$ indicates the sample mean and n indicates the sample number. ("n" is a positive integer.)
- As a hypothesis, $\mu \neq \mu_0$ (double side test) is found using the obtained sample data.

3. The cursor pointer is located at $\mu \neq \mu_0$ initially.
   Press ▼ to move the cursor pointer to $\mu_0$ ($\mu \neq \mu_0$ will be highlighted, indicating that it has been selected).
4. Press 52.4 ENTER to input the hypothesized value of $\mu_0$.
5. Press 4.5 ENTER to input the value of σ.
6. Press 53.4 ENTER to input the value of $\bar{x}$.
7. Press 20 ENTER to input the value of n (as shown to the right).




8. Press 2ndF EXE to solve. The answer shown to the right will be displayed.




* z indicates statistics and P indicates probability.

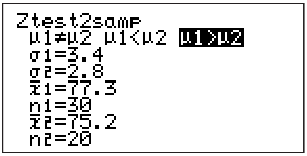
**[09 Ztest2samp]**

Tests the identity of two sample means, $\mu_1$ and $\mu_2$, when the population standard deviation, $\sigma_1$ and $\sigma_2$, from two sample data sets collected from two different populations, are known.

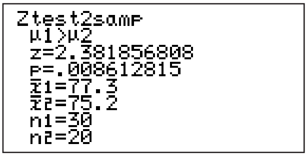
**<Example 9>**

$\mu_1 > \mu_2$ is the test for two sets of sample data: $\overline{x}_1 = 77.3$, $\sigma_1 = 3.4$, $n_1 = 30$ and $\overline{x}_2 = 75.2$, $\sigma_2 = 2.8$, $n_2 = 20$ ($\overline{x}_1$ and $\overline{x}_2$ indicate each sample mean).

1. Set to the numerical value input mode (InputList).
2. Press [STAT] [E] [0] [9] to open the parameter input screen.
   Input each obtained parameter and test method (the screen to the right shows the screen with input complete).




3. Press [2ndF] [EXE] to solve. The answer will be displayed as shown to the right.




* "n1" and "n2" are positive integers.

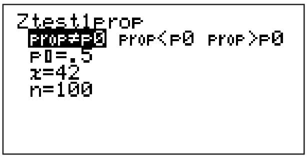
**[10 Ztest1prop]**

Tests the success probability $P_0$ of a population. $P_0$ is the success probability obtained from sample data collected from a population.

**<Example 10>**

A coin was tossed 100 times and landed heads side up 42 times. Normally, the probability of heads facing up is 0.5, but we will test this obtained sample data (test using prop $\neq P_0$).

1. Press [STAT] [E] [1] [0] to input each parameter.

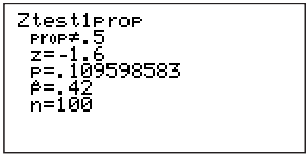



* "prop" shows the success probability of population estimated from the obtained success probability (since the test will be conducted using hypothesis prop  $P_0$, the screen will look like the one shown to the right).

* x indicates the success number and n indicates the trial number. ("n" is a positive integer.)

2. Press [2ndF] [EXE] to obtain the answer as shown to the right.

* $\hat{P}$ indicates the success probability obtained from the sample data.



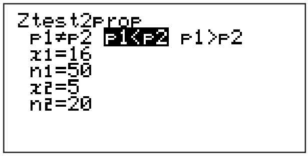

**[11 Ztest2prop]**

Executes comparative test for the success probability, (P1, P2), obtained from two sets of sample data collected from two different populations.

**<Example11>**

Here, we will test the success probability of P1 and P2 using the hypothesis, P1 < P2, for the two sets of sample data $n_1 = 50$, $x_1 = 16$ and $n_2 = 20$, $x_2 = 5$.

1. Press [STAT] [E] [1] [1] to input each parameter (as shown to the right).

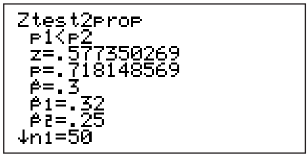


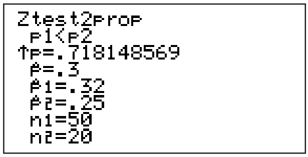

2. Press [2ndF] [EXE] to obtain answer as shown to the right.
   The answer is given using two screens.

* $\hat{P}$ indicates the calculated success rate of sample data 1 and 2 combined.

* $\widehat{P_1}$ and $\widehat{P_2}$ show the success rates of each set of sample data.

* "n1" and "n2" are positive integers.



**[12 Zint1samp]**

Finds the confidence bound of the population mean, $\mu$, when the value of the population standard deviation, $\sigma$, from sample data collected from a population, is known.

**<Example 12>**

Here, we will find the confidence bound of the sample data from example 8 ($\mu$) when the level of confidence (C-level) is 0.95.

1. Set to the numerical value input mode (InputStat).
2. Press STAT E 1 2 to input each parameter (as shown to the right).

```
Zint1samp
 σ=4.5
 C-level=.95
 x̄=53.4
 n=20
```

3. Press 2ndF EXE to solve (as shown to the right).

```
Zint1samp
 (51.427824,55.372176)
 x̄=53.4
 n=20
```

The numerical value within () indicates the confidence bound with the level of confidence at 0.95.
In other words, the confidence bound of this sample data with the confidence level at 95% is between 51.428… and 55.372….

* C-level indicates the level of confidence.

* “n” is a positive integer.

**[13 Zint2samp]**

Finds the confidence bound of two sample means, “$\mu_1$, $\mu_2$”, when each population standard deviation, “$\sigma_1$, $\sigma_2$”, from two sets of sample data collected from two different populations, are known.

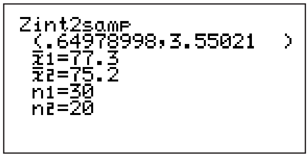
**<Example 13>**

Here, we will find the confidence bound of $\mu_1$ and $\mu_2$ using contents from example 9 with the confidence level at 0.9.

1. Set to the numerical value input mode (InputStat).
2. Press STAT E 1 3 to input each parameter (as shown to the right).

```
Zint2samp
 σ1=3.4
 σ2=2.8
 C-level=.9
 x̄1=77.3
 n1=30
 x̄2=75.2
 n2=20
```

3. Press [2ndF] [EXE] to solve (as shown to the right). The numerical value within () indicates the confidence bound of $\mu_1$ and $\mu_2$ when the confidence level is 90%.




* "n1" and "n2" are positive integers.

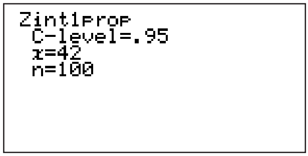
**[14 Zint1prop]**

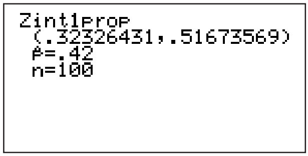
Finds the confidence bound of the success probability of a population from the success probability obtained from sample data collected from a population.

**<Example 14>**

Here, we will find the confidence bound of the success probability of contents from example 10 with confidence level at 0.95.

1. Press [STAT] [E] [1] [4] to input each parameter (as shown to the right).




2. Press [2ndF] [EXE] to solve (as shown to the right). The numerical value within () indicates the confidence bound of the success probability with confidence level at 95%.

* "n" is a positive integer.

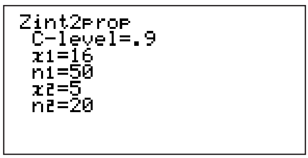
**[15 Zint2prop]**

Finds the confidence bound of the difference (P1 - P2) of the success probability obtained from two sets of sample data collected from two different populations.

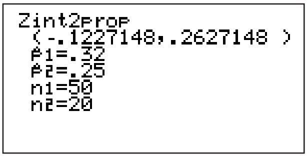
**<Example 15>**

Here, we will find the confidence bound of the success probability of contents from example 11 with the confidence level at 0.9.

1. Press [STAT] [E] [1] [5] to input each parameter (as shown to the right).



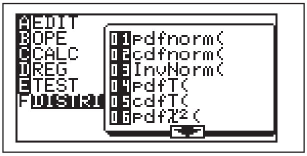
2. Press [2ndF] [EXE] to solve (as shown to the right).
   The numerical value within () indicates the confidence bound of success probability P1 - P2 with the confidence level at 90%.



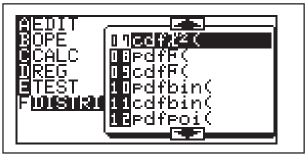

* "n1" and "n2" are positive integers.

# 4. Distribution Function

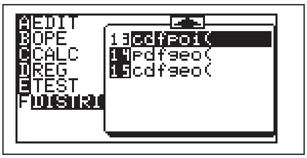
- The calculator is equipped with a distribution calculation function to find the distribution of a statistic.
- To execute a calculation using the distribution function, press [STAT] and select [F DISTRI].
- There are 15 options within the [F DISTRI] menu (check by pressing [ALPHA] [▼]).
- To use a distribution function, first press [STAT] [F] in the standard function calculation screen, select desired function from the sub-menu list, then transfer the desired function to the standard function calculation screen by pressing [ENTER].
  For example, to use [04 pdfT]:
  The following function will appear when pressing [⊞] [STAT] [F] [0] [4].

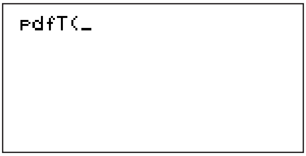



↓ [▶] [ALPHA] [▼]




↓ [ALPHA] [▼]




- After displaying the function name on the screen, input each specified value then press [ENTER] to solve.
- Below is an explanation of the menus and input values.

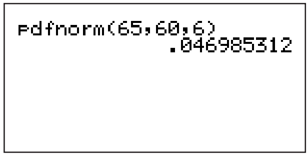
**[01 pdfnorm(]**: Finds the probability density of a specified value x for the normal distribution N($\mu$, $\sigma^2$)(cannot be input using lists).
Format: pdfnorm (value of x, mean, standard deviation) However, mean ($\mu$) and standard deviation ($\sigma$) may be omitted. (When omitted, $\mu$=0 and $\sigma$=1.)

**<Example 1>**

Find the normal distribution probability density for x = 65 when the normal distribution of test scores averages 60, with a standard deviation of 6.

Key operation:

[+−×÷] [STAT] [F] [0] [1] 65 [,] 60 [,] 6 [)] [ENTER]



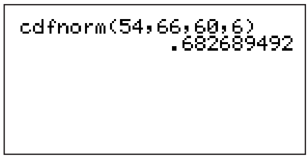

**[02 cdfnorm(]**: Calculates the normal distribution probability of a specified range x for normal distribution N ($\mu$, $\sigma^2$)(cannot be entered using lists).
Format: cdfnorm (lower value, upper value, mean, standard deviation) However the mean and standard deviation may be omitted. (When omitted, $\mu$=0 and $\sigma$=1.)

**<Example 2>**

Calculate the probability of range “x = 54 to 66” in example 1.

Key operation:

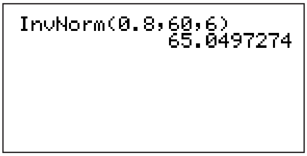
[+−×÷] [STAT] [F] [0] [2] 54 [,] 66 [,] 60 [,] 6 [)] [ENTER]




**[03 InvNorm (]**: Finds the value of x of a given normal distribution probability (cannot be entered using lists).
Format: InvNorm (probability, mean, standard deviation) However, the mean and standard deviation may be omitted. (When omitted, $\mu$=0 and $\sigma$=1.)

**<Example 3>**

Find the value of x when the probability of example 1 is 0.8.




Key operation:

[+−×÷] [STAT] [F] [0] [3] 0.8 [,] 60 [,] 6 [)] [ENTER]

Thus, all of the probabilities for data with x up to 65 are 0.8.

**[04 pdfT (]**: Finds the probability density of a specified value x for T distribution with n degrees of freedom (cannot be entered using lists).

Format: pdfT (value of x, degrees of freedom)

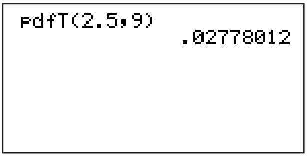
* Degrees of freedom is a positive real number.
If decimals are used for the degrees of freedom, the closest calculation is executed using the supplied degrees of freedom as an integer.

**<Example 4>**

Find the probability density of T distribution with 9 degrees of freedom when “x = 2.5”.

Key operation:

[+−×÷] [STAT] [F] [0] [4] 2.5 [,] 9 [)] [ENTER]




* An error may occur when entering an extremely large number (exceeding 100, etc.) for the degrees of freedom.

**[05 cdfT (]**: Finds the T distribution probability within the specified range of x for T distribution with n degrees of freedom (cannot be entered using lists).

Format: cdfT (lower limit, upper limit, degrees of freedom)

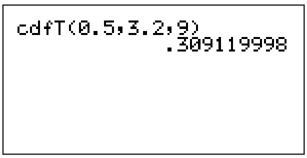
* Degrees of freedom is a positive real number.
If decimals are used for the degrees of freedom, the closest calculation is executed using the supplied degrees of freedom as an integer.

**<Example 5>**

Find the probability of range X = 0.5 to 3.2 for T distribution with 9 degrees of freedom.

Key operation:

[+−×÷] [STAT] [F] [0] [5] 2.5 [,] 9 [)] [ENTER]



**[06 pdf$\chi^2$ (]**: Finds the probability density of specified value x for $\chi^2$ distribution with n degrees of freedom (cannot be entered using lists).

Format: pdf$\chi^2$ (value of x, degrees of freedom)

* Degrees of freedom is a positive integer.

**<Example 6>**

Find the probability density of $\chi^2$ distribution with 15 degrees of freedom when “x = 6.5”.

Key operation:

[MATH] [STAT] [F] [0] [6] 6.5 [,] 15 [)] [ENTER]

```
pdfχ²(6.5,15)
           .022010097
```

**[07 cdf$\chi^2$ (]**: Finds the $x^2$ distribution probability of a specified range of x for $\chi^2$ distribution with n degrees of freedom (cannot be entered using lists).

Format: cdf$\chi^2$ (lower limit, upper limit, degrees of freedom)

* Degrees of freedom is a positive integer.

**<Example 7>**

Find the probability of range “x = 3 to 15” for $\chi^2$ distribution with 10 degrees of freedom.

Key operation:

[MATH] [STAT] [F] [0] [7] 3 [,] 15 [,] 10 [)] [ENTER]

```
cdfχ²(3,15,10)
           .849362207
```

**[08 pdfF (]**: Finds the probability density of specified value x for F distribution that possesses two independent degrees of freedom, m and n (cannot be entered using lists).

Format: pdfF (value of x, degrees of freedom of numerator, degrees of freedom of denominator)

* Degrees of freedom for m and n are positive integers.

**<Example 8>**

Find the probability density for F distribution generated with degrees of freedom 15 and 10 when “x = 3”.

Key operation:

[MATH] [STAT] [F] [0] [8] 3 [,] 15 [,] 10 [)] [ENTER]

* An error may occur when entering an extremely large number (exceeding 100, etc.) for the degrees of freedom.

```
pdfF(3,15,10)
           .044804194
```

**[09 cdfF (]**: Finds the F distribution probability of specified range x for F distribution with two independent degrees of freedom, m and n (cannot be entered using lists).
Format: cdfF (lower limit, upper limit, degrees of freedom of the numerator, degrees of freedom of denominator) However, the degrees of freedom of the numerator and the degrees of freedom of the denominator may be omitted.

**<Example 9>**

Find the probability of range “x = 0  to 2.5” for F distribution generated with degrees of freedom 15 and 10.

Key operation:

STAT F 0 9 0 , 2.5 , 15 , 10 ) ENTER

```
cdfF(0,2.5,15,10)
          .926291613
```

* An error may occur when entering an extremely large number (exceeding 100, etc.) for the degrees of freedom.

**[10 pdfbin (]**: Finds the probability density of specified value x for binomial distribution (cannot be entered using lists, with the exception of success numbers).
Format: pdfbin (trial number, success probability, success number) However the success number may be omitted (when the success number is not specified, the calculation is executed by entering values from 0 to the trial number and displays the list).

* The success probability is 0≤p≤1.

**<Example 10>**

There is a binomial distribution with success probability of 30%. Find the probability density for 15 trials with “x = 7”.

Key operation:

STAT F 1 0 15 , 0.3 , 7 ) ENTER

```
pdfbin(15,0.3,7)
          .081130033
```

**[11 cdfbin (]**: Finds the probability of a specified range x of a binomial distribution (cannot be entered using lists, with the exception of success numbers).
Format: cdfbin (trial number, success probability, success number) However, the success number may be omitted (when the success number is not specified, values from 0 to the trial number are entered and displayed as list).

**<Example 11>**

Find the probability of example 9 using range up to “x = 7”.

Key operation:

[STAT] [F] [1] [1] 15 [,] 0.3 [,] 7 [)] [ENTER]

```
cdfbin(15,0.3,7)
             .949987459
```

**[12 pdfpoi (]**: Finds the probability density of a specified value x for a Poisson distribution of mean μ.
Format: pdfpoi (mean, value of x)

**<Example 12>**

Find the probability density of “x = 4”, when the mean of a Poisson distribution is 3.6.

Key operation:

[STAT] [F] [1] [2] 3.6 [,] 4 [)] [ENTER]

```
pdfpoi(3.6,4)
             .191222339
```

**[13 cdfpoi (]**: Finds the probability of specified range x for a Poisson distribution of mean μ.
Format: cdfpoi (mean, value of x)

**<Example 13>**

Finds the probability within the range up to “X = 4”.

Key operation:

[STAT] [F] [1] [3] 3.6 [,] 4 [)] [ENTER]

```
cdfpoi(3.6,4)
             .706438449
```

**[14 pdfgeo (]**: Finds the probability density of specified value x for a geometric distribution.

Format: pdfgeo (success probability, value of x)

* The success probability is 0≤p≤1.

**<Example 14>**

Find the probability density of a geometric distribution with success probability of 5.6% that it will be successful the 26th time.

Key operation:

[+−×÷] [STAT] [F] [1] [4] 0.056 [,] 26 [)] [ENTER]

```
pdfgeo(0.056,26)
           .013258301
```

**[15 cdfgeo (]**: Finds the probability of a specified range of x for geometric distribution.

Format: cdfgeo (success probability, value of x)

**<Example 15>**

Find the probability for example 14 using range up to x = 26.

Key operation:

[+−×÷] [STAT] [F] [1] [5] 0.056 [,] 26 [)] [ENTER]

```
cdfgeo(0.056,26)
            .77650292
```

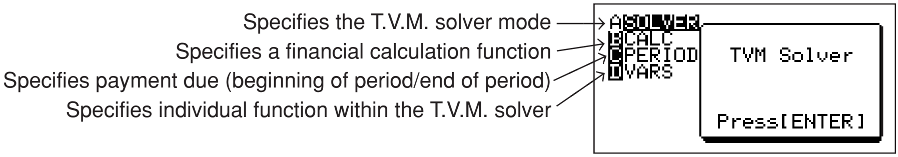
## Limitations for calculating the distribution function:

For the following statistical distribution functions, the range of degree of freedom in which calculation can be made is limited to those shown below.

| | |
|---|---|
| 1) pdfT( | Degrees of freedom ≤ 140 |
| 2) cdfT( | Degrees of freedom ≤ 670 |
| 3) pdf$\chi^2$ | Degrees of freedom ≤ 141 |
| 4) pdfF( | Degrees of freedom ≤ 70 |
| 5) cdfF( | Degrees of freedom ≤ 670 (For both degrees of freedom to be input) |
| 6) pdfpoi( | Mean of poisson distribution ≤ 230 |
| 7) cdfgeo( | Success probability is 0 ≤ p ≤ 1 |

# CHAPTER 8
# FINANCIAL FUNCTIONS

- The financial calculation commands of the calculator are located in the Financial menu.
- Press [2ndF] [FINANCE] to execute financial calculations ([FINANCE] is the second function of [÷]).
- Numerical value input format and display format in the FINANCE mode comply to that of SET UP.
- Pressing [2ndF] [FINANCE] displays the menu screen shown below. The outline of the main menu is as follows:




## 1. Before Starting Financial Calculations

### (1) Differences between simple interest and compound interest

- There are two ways to calculate interest: simple interest and compound interest. The calculator is capable of executing, both simple and compound interest calculations.

**The differences between simple interest and compound interest:**
For example, what would the difference be for simple interest and compound interest when depositing $10,000 (principal sum) in a bank for a period of three years at an annual interest rate of 3%?

Simple interest:

- Annual interest rate of 3% means that 3% interest of $10,000 will be received for the first year or $300.
- Since the principal sum remains the same, the interest for the second year would also be: $10,000 × 0.03 (3%) = $300.
- Thus, the total interest after a period of three years would be $900, as indicated below.
  $10,000 (principal sum) × 0.03 (interest) × 3 (number of years deposited) = $900

Compound interest:

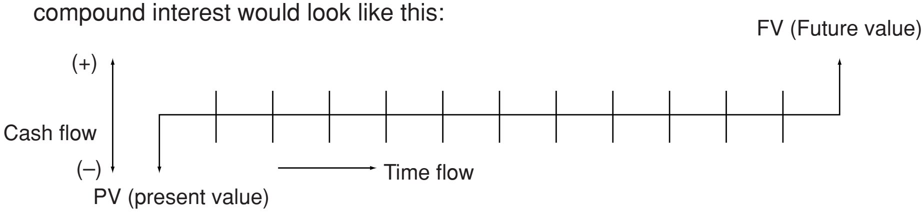
- The interest for the first year would be $300 ($10,000 × 0.03), which is the same as for simple interest.
- The interest for the second year is calculated by adding the interest gained in the first year to the principal sum. Thus, interest of $309 (($10,000 + $300) × 0.03) would be received.
- The interest for the third year is calculated by adding the interest gained in the second year, which is $318.27 as indicated below.
  ($10,300 + $309) × 0.03 = $318.27
- Thus, the total interest received in the period of three years would be $927.27 ($300 + $309 + $318.27)

- As can be seen in the above example, there is a difference of $27.27 ($927.27 – $900) after three years for simple interest and compound interest, although the interest rate is the same.
- For compound interest, the amount in the bank is increased by receiving interest on the interest gained during each calculated period.

## (2) Cash flow diagrams

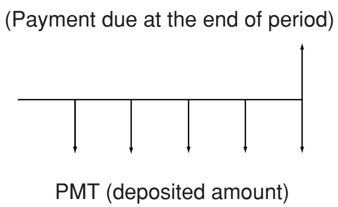
Cash flow diagrams show cash flow by time in a form of a diagram. Cash flow diagrams are created with the following items in mind.

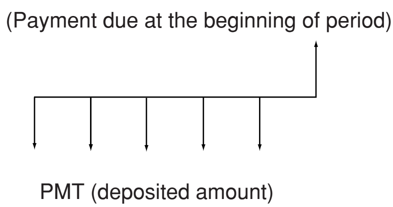
- Time flow is indicated using a horizontal line. Time flow moves from left to right. Time is divided into even sections (day, month, quarter periods, half year, year, etc.). Each section indicates a compound interest period and the total number of sections indicates the total number of periods.
- Cash flow is indicated using a vertical line with arrows. Inflow of cash is indicated using a UP arrow as plus and outflow of cash is indicated using a DOWN arrow as minus.
- For this calculator, the cash flow for each period is considered the same (even payment).
  For example, the cash flow diagram used to find the principal sum total of standard compound interest would look like this:




Since the present value (PV) is deposited into the bank, it is considered an outflow (payment) from the customer's point of view. Thus, a vertical line with an arrow is drawn on the bottom (minus) of the diagram. Since principal interest total is received from the bank, it is considered an inflow (revenue) from the customer's point of view. Thus, a vertical line with an arrow is drawn on the top of the diagram.

Diagrams for deposits and loan payments have payment due at the beginning and end of each period. Thus, producing a cash flow diagram is somewhat different than that described above.



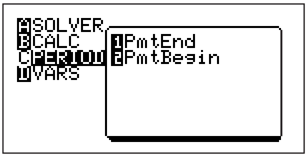

When executing financial calculations, it is recommended to display contents using such cash flow diagrams to simplify problems for easier calculations.

# 2. The Financial Function

## (1) Setting of payment due (at the beginning/end of a period)

- With the calculator, it is possible to set whether payments are due at the beginning of a period or at the end of a period.
- Payments due at end of a period means that payments are made at the end of each period. Payments due at the beginning of a period means that payments are made at the beginning of each period.
- The only difference is that the interest for a payment due is lower for the amount paid at the beginning of each period.
- Usually, loan payments are due at the end of each period.
- Payment due setting is specified in the FINANCE menu.

1. Press 2ndF FINANCE. Since specification of payment due is located in [C PERIOD], press C to open the sub-menu (the screen to the right will appear).



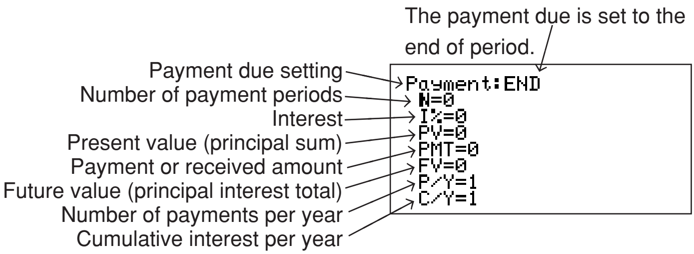

2. Press 1 ENTER (PmtEnd) to specify payment due at the end of a period and 2 ENTER (PmtBegin) to specify payment due at the beginning of a period.

- The content specified here will be reflected in the calculation results.

## (2) SOLVER function

- The calculator is equipped with a SOLVER function that calculates number of payments (N), interest (i), present value = principal sum (PV), payment or received amount (PMT), future value = principal interest total (FV), etc. at one time.
- The SOLVER function is described in CHAPTER 9 on page 211 and is a function that solves one unknown variable by inputting known variables.
- To execute the SOLVER, press 2ndF FINANCE then press A ENTER.
  (To differentiate from the method used in standard functions, the SOLVER function for finance is called the TVM-SOLVER).

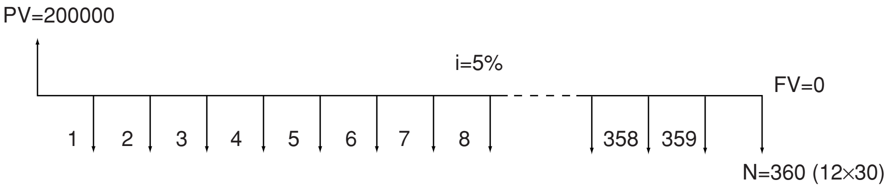
- The following screen will appear when entering the TVM SOLVER mode.




**<Example 1>**

There is plan to purchase a house for a price of $300,000. The down payment is $100,000. We will calculate the monthly payments for a 30 year loan at an annual interest rate of 5% for the remaining $200,000.

- First, draw the cash flow for this problem (payments are due at the end of period).




We will then input known variables (the following key operation is executed while in the TVM SOLVER screen).

1. Press 360 [ENTER] to input 360 (number of monthly payments for 30 years) for N (number of payments).

The cursor pointer moves to “I%” and the annual interest can be entered.

2. Input I% (annual interest).
   5 [ENTER]
3. Input PV (present value) (in this case, it is the loaned $200,000).
   200000 [ENTER]
4. Press [ENTER].
   Since the payment amount has been solved, PMT is skipped without entry and the cursor is moved down (“0” will be displayed).
5. Press [ENTER].
   Since the FV (future value) will be “0” at the end (remaining loan), [ENTER] is pressed to display “0”.

6. Press 12 ENTER.
   Since P/Y (number of payments per year) is monthly, there will be 12 payments annually.
7. Press ENTER.
   C/Y (cumulative interest per year) is given the same numerical value as the entered P/Y. Since there are 12 monthly payments, annual interest is naturally calculated in the same manner.
8. Press ▲ ▲ ▲.
   Move the cursor pointer to the location of "PMT" (it is also possible to touch [PMT] using the touch pen).
9. Press 2ndF EXE .
   Calculation is executed and the result shown to the right is obtained.

```
Payment:END
 N=360
 I%=5
 PV=200000
*PMT=-1073.643246
 FV=0
 P/Y=12
 C/Y=12
```

- Result: PMT=-1073.643246
  (This is due to the FSE setting being set to FloatPt in the SET UP menu. Calculation results can be modified using appropriate TAB settings. The answer above would be displayed "1073.64" when setting to TAB: 2, FSE: FIX).
- The negative PMT display indicates payments.

**<Example 2>**

We calculate the down payment amount for the above example when the limit for monthly payments is $800. At the same time, we will set "TAB: 2, FSE: FIX" to modify the calculation result.

1. First we will set TAB to "2" and FSE to "FIX".
   2ndF SET UP C 2 D 2
2. Display the previous TVM SOLVER screen by pressing CL 2ndF FINANCE A ENTER (the cursor pointer will again flash at "N".)

```
Payment:END
 N=360.00
 I%=5.00
*PV=149025.29
 PMT=-800.00
 FV=.00
 P/Y=12.00
 C/Y=12.00
```

3. Press [▼] [▼] [▼] [(—)] 800 [ENTER] to input "-800" for "PMT".
4. Press [▼] 12 [ENTER] [▲] [▲] [▲] [▲] to move the cursor pointer to the location of PV.
5. Press [2ndF] [EXE] to solve.

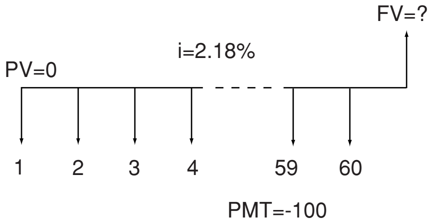
- Result: PV = 149025.29
- This shows the limit of payable amount for monthly payments of $800.
- Thus, the amount needed for the down payment is $150,974.71 ($300,000 - $149,025.29)

In the TVM SOLVER screen, it is easy to obtain various results by inputting known variables such as payment periods to 20, 25, and 30 years to simulate payments, as well as freely setting the unknown variable (variable to solve).

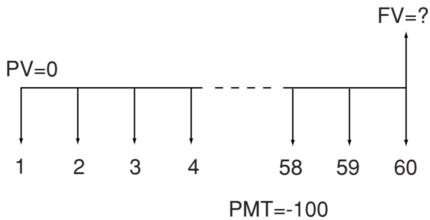
**<Example 3>**

We will compare the principal interest total for accumulated interest of $100 monthly at 2.18% for 5 years. The cash flow diagrams for the payment due at the beginning and end of the period are as follows (TAB is set to 2):

Payment due at beginning of period

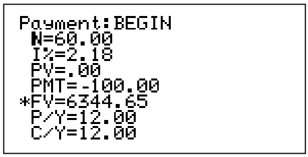



Payment due at end of period



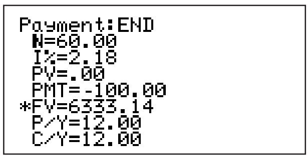

① Payment due at beginning of period

1. Press [2ndF] [FINANCE] [C] [2] [ENTER] to set to payment due at beginning of period.
2. Press [2ndF] [FINANCE] [A] [ENTER] to specify the TVM SOLVER.
3. Press 60 [ENTER] 2.18 [ENTER] 0 [ENTER] [(—)] 100 [ENTER] [▼] 12 [ENTER] to input known variables.
4. Press [▲] [▲] [2ndF] [EXE] to move the cursor to FV and solve.




② Payment due at end of period

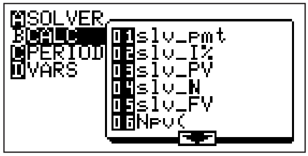
1. Press [2ndF] [FINANCE] [C] [1] [ENTER] to set to payment due at end of period.
2. Press [2ndF] [FINANCE] [A] [ENTER].



3. Press ▼ ▼ ▼ ▼ 2ndF EXE to calculate FV by using the numerical value entered in the above example.

## (3) Calculation using the CALC mode

- In the CALC menu of the FINANCE menu are functions designated for finance calculations.
- Press 2ndF FINANCE B to check the contents of the CALC menu.
- 01 to 06 calculates each variable displayed on the previous TVM SOLVER screen.




**<Example 4>**

Here, we are asked to make monthly payments for a sum of $200,000 at interest of 5% for 30 years.

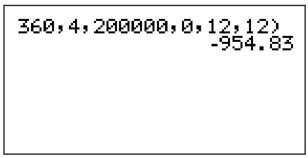
We will simulate on the standard function calculation screen how the results change when changing conditions of various variables.

**[01 slv_pmt] :** Calculates monthly payments.

Input method: input variable other than PMT, such as slv_pmt (N, I%, PV, FV, P/Y, C/Y), to solve PMT (TAB is set to 2).

Find the result when changing interest from 5% to 4%.

1. Press CL.
   Recall the normal function calculation screen and clear unnecessary display.
2. Press 2ndF FINANCE C 1 ENTER to set PmtEnd.
3. Press 2ndF FINANCE B 0 1 to display "slv_pmt" on-screen.

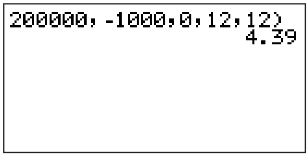



4. Input known variables ( 360 , 4 , 200000 , 0 , 12 , 12 ).
5. Pressing ENTER displays the monthly payments (PMT) at interest rate of 4%.
   Thus, it shows that the monthly payments are reduced from $1073.62 at 5% to $954.83 at 4%.

**[02 slv_I%] :** Calculates annual interest

Input method: slv_I%(N, PV, PMT, FV, P/Y, C/Y)

Here, we will calculate the interest to establish a monthly payment of $1000 (TAB is set to 2).




[CL] [2ndF] [FINANCE] [B] [0] [2]

[(] 360 [,] 200000 [,] [(–)] 1000 [,] 0 [,]

12 [,] 12 [)] [ENTER]

Thus, monthly payments of $1000 are possible at interest rate of 4.39%

- It is possible to find out an unknown variable by inputting known variable for the functions described below.
- However, the contents simulated on the home screen do not influence the variable values of the TVM SOLVER.

**[03 slv_PV] :** Calculates the present value.

Input method: slv_PV(N, I%, PMT, FV, P/Y, C/Y)

**[04 slv_N] :** Calculates the number of payments.

Input method: slv_N(I%, PV, PMT, FV, P/Y, C/Y)

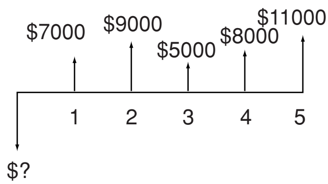
**[05 slv_FV] :** Calculates the future value.

Input method: slv_FV (N, I%, PV, PMT, P/Y, C/Y)

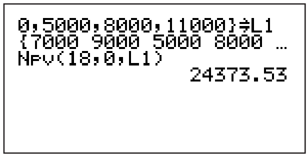
**[06 Npv (] :** Calculates the pure initial value and evaluates the validity of the investment.

**<Example 5>**

There is a plan of raising the initial investment to increase sales each year, as shown to the right. How much would the initial investment have to be in order to increase the annual revenue of 18%?




- "Npv(" is used in such a case to calculate investment.
- Input method: Npv(interest rate, initial investment, list of following collected investment)




* Annual sales (collected investment) are input in a list format.

- This is explained using the following key procedure.

1. Press [⊞] [CL] to recall standard function calculation screen and clear screen.
2. Input collected investment data to list L1.
   [2ndF] [{] 7000 [,] 9000 [,] 5000 [,] 8000 [,] 11000 [2ndF] [}] [STO] [2ndF] [L1] [ENTER]
3. Calculate NPV.
   [2ndF] [FINANCE] [B] [0] [6] 18 [,] 0 [,] [2ndF] [L1] [)] [ENTER]

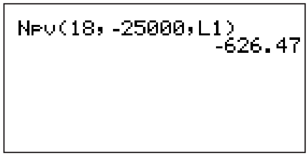
- Thus, an initial investment of $24,373.53 allows revenue to be secured at 18% using the sales plan above.

* Input initial investment value for the equation above: 0. This is to find the one-time investment payment.

**<Example 6>**

To find out whether the revenue of 18% can be secured with an investment of $25,000 using example 5 above, enter “25000” as the investment instead of “0”.

- [⊞] [CL]
- [2ndF] [FINANCE] [B] [0] [6] 18 [,] [(−)] 25000 [,] [2ndF] [L1] [)] [ENTER]

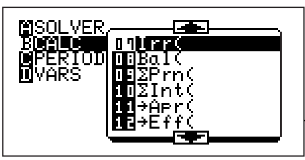



* Negative numbers indicate outflow of cash (investment).

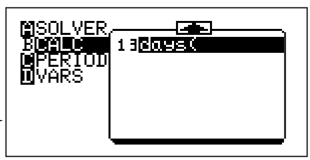
- The answer will be -626.47. A negative sign is attached.
  Thus, revenue of 18% cannot be secured using the sales plan above with an investment of $25,000.

Next, we will explain functions [07] and on. First, we will check the contents of the CALC sub-menu.

- Display 07 to 12 by pressing [2ndF] [FINANCE] [B] [▶] [ALPHA] [▼]




Check the next page as well [ALPHA] [▼]



**[07 Irr] :** Calculates the investment revenue rate.

Input method: Irr (initial investment, list of following collected investment)

**<Example 7>**

The investment revenue rate is calculated using example 5 by assuming an investment of $28,000 for the sales plan. (The sales plan is considered entered in list L1 and TAB is set to “2”).

1. [+−×÷] [CL]
2. [2ndF] [FINANCE] [B] [0] [7] [(—)] 28000 [,] [2ndF] [L1] [)] [ENTER]

```
Irr(-28000,L1)
             12.42
```

- 12.42 is obtained as the answer. Thus, the investment revenue rate for the above condition is 12.42%

* In the previous example, revenues following the investment value (input using “-” symbol) were assumed to be positive. However, when the assumed revenue is set to minus (in other words, more than two inverse symbols), the assumed revenue rate must be entered at the end. Error is returned unless this is done.

Input method: Irr (Initial investment value, list of collected investment, assumed revenue rate)

**[08 Bal (] :** Calculates payments.

Input method: Bal (number of payments, displayed number of decimals).

The displayed number of decimals is optional (TAB setting will be valid in this case).

**<Example 8>**

We will calculate the loan balance after 15 years (180 months), using the contents set in example 1.

1. [+−×÷] [CL]
2. [2ndF] [FINANCE] [B] [0] [8] 180 [)] [ENTER]

Thus, the remaining loan balance is $135,767.82

```
Bal(180)
         135767.82
```

**[09 ΣPrn (] :** Calculates the amount of principals in the total payment.

Input method: ΣPrn (initial number of payments, end number of payments, displayed number of decimals).

The displayed number of decimals is optional.

**<Example 9>**

We will compare the amount of principals in the total payment after 5 years (1 to 60) and 10 years (61 to 120) using example 1.

1. [CL]
2. [2ndF] [FINANCE] [B] [0] [9] 1 [,] 60 [)] [ENTER]
3. [2ndF] [FINANCE] [B] [0] [9] 61 [,] 120 [)] [ENTER]

```
ΣPrn(1,60)
            -16342.54
ΣPrn(61,120)
            -20973.34
```

As it can be seen, the payments dominating the principal sum are greater for years 6 to10 when compared to the first through the fifth years (negative indicates payment).

**[10 ΣInt (] :** Calculates the sum of interest dominating the payment sum.
Input method: ΣInt (Initial number of payments, end number of payments, displayed number of decimals).
The displayed number of decimals is optional.

**<Example 10>**

We will compare the sum of the interest dominating the payment sum after 5 years and 10 years, as with example 9.

1. [CL]
2. [2ndF] [FINANCE] [B] [1] [0] 1 [,] 60 [)] [ENTER]
3. [2ndF] [FINANCE] [B] [1] [0] 61 [,] 120 [)] [ENTER]

```
ΣInt(1,60)
            -48076.06
ΣInt(61,120)
            -43445.26
```

* Calculations cannot be executed for [08 Bal(], [09 ΣPrn(] and [10 ΣInt(] if the known variables of example 1 are not entered.
(for execution of calculation, numerical values must be entered to I%, PV and PMT)

**[11 →Apr (] :** Converts effective interest rate to nominal interest rate.
Input method: →Apr (effective interest rate, number of settlements)

**<Example 11>**

How much is the nominal interest rate for the quarterly compound interest (every three months) when the effective interest rate is 12.55%? What would the nominal interest rate be when monthly compound interest rate is 10.5%? (TAB setting is 2).

```
→Apr(12.55,4)
            12.00
→Apr(10.5,12)
            10.03
```

1. [CL]
2. [2ndF] [FINANCE] [B] [1] [1] 12.55 [,] 4 [)] [ENTER]
   Ans: The nominal interest rate is 12.00%
3. [2ndF] [FINANCE] [B] [1] [1] 10.5 [,] 12 [)] [ENTER]
   Ans: The nominal interest rate is 10.03%

**[12 →Eff (]:** Converts nominal interest rate to effective interest rate.
Input method: →Eff (nominal interest rate, number of settlements)

```
→Eff(8,12)
                8.30
→Eff(8,2)
                8.16
```

**<Example 12>**
What would the effective interest rate for monthly compound interest be with 8% as the annual interest rate? How much would it be for half a year?
The TAB is set to “2”.

1. [+−×÷] [CL]
2. [2ndF] [FINANCE] [B] [1] [2] 8 [,] 12 [)] [ENTER]
   Finds the monthly compound interest rate.
   Ans: 8.3% for monthly compound interest rate
3. [2ndF] [FINANCE] [B] [1] [2] 8 [,] 2 [)] [ENTER]
   Finds the compound interest rate for half a year.
   Ans: 8.16% for compound interest rate for half a year

* Effective interest rate converts annual interest rate to monthly or quarterly (three months) or semi-annually (six months) for compound interests. The nominal interest rate shows the annual interest rate.

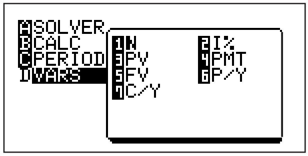
**[13 days (]:** Calculates days (the calculation range is 1950 to 2049).
Input method: days (start month. day year, end month. day year) or days (day month. year, day month. year)
Years/months/days are entered using 2 digits. For example 1997 would be 97.

**<Example 13>**
Calculate number of days from September 1, 1997 to December 31, 1999.

```
days(9.0197,12.3199)
              851.00
```

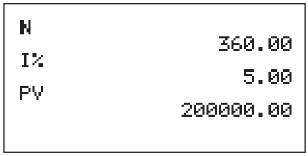
1. [+−×÷] [CL]
2. [2ndF] [FINANCE] [B] [1] [3] 9 [·] 0197 [,] 12 [·] 3199 [)] [ENTER]
   Ans: 851 days

## (4) VARS menu




- The VARS menu is installed with all functions used in the TVM SOLVER.
- Press 2ndF FINANCE D to display all sub-menu items within the VARS menu.
- The functions of these menus are the same as that of the previously described SOLVER.
- These SOLVER functions can be recalled from the standard function calculation screen.
- To recall: press 2ndF FINANCE D

Try recalling these functions with the TVM SOLVER of Example1 executed.




CL 2ndF FINANCE D 1 ENTER : Recalls the content of N

2ndF FINANCE D 2 ENTER : Recalls the content of I%

2ndF FINANCE D 3 ENTER : Recalls the content of PV

- As is shown, these functions can recall contents of the TVM solver and input numerical values to these functions (for example, to input a numerical value, use the STO key as with 400 ⇒ N).

# CHAPTER 9
# SOLVER FUNCTION

- The calculator allows you to find the solution of equations. This chapter describes how to input an equation and find the solution.
- The basic flow is as follows.

1. Enter the solver mode (2ndF SOLVER).
2. Input an equation.
3. Input numeric values for known variables.
4. Calculate unknown variables. (There are three kinds of calculation methods available.)

An equation which is frequently used can be stored and called up when necessary.

* To exit the SOLVER mode, press +−×÷.

## 1. Inputting an Equation and Finding Its Solution

1. To use the solver function, press 2ndF SOLVER.
   The message “SOLVER” momentarily appears, showing that operation has entered the solver mode, and then the equation input screen appears.

```
SOLVER
```

2. To input an equation :

```
_
```

- It is possible to use functions assigned to the keyboard and some of the menu functions.
- 27 characters, A to Z, and θ can be used for variables.
- One character is defined as one variable. (For example, ABC means A × B × C.)
- Variables A to Z and θ correspond to independent memory spaces. For example, the variable A and independent memory A are the same.
  Independent memory spaces may directly use the contents of other equations, programs, and calculations as they are already stored. Conversely, values found by the solver function can also be used by other equations and programs through independent memory spaces.
- Equations can be input in one line edit mode or in equation edit mode.
  It is not necessary to input an equation in the format of left side = right side.
  For example, an equation such as “A + B + C” can be input. (At this time, the calculator assumes the equation to be “A + B + C = 0”, and performs the calculation.)

3. To find the solution:
   When ENTER is pressed after the equation has been input, the calculator enters the variable input screen.
   Input numeric values for the known variables, then move the cursor pointer to a variable for which you wish to obtain the solution. Press 2ndF EXE to find the solution.
   Even though the numeric value already exists in the variable for which you wish to obtain the solution, if values in other variables are changed, recalculation is performed to find the solution. "■" flashes at the upper right corner of the screen during calculation.

**<Example>**

Enter the equation "A = 3B –C + D", to find the value C in the case of A=10, B=3, and D=-5.

1. ALPHA A ALPHA = 3 ALPHA B − ALPHA C + ALPHA D

```
A=3B-C+D_
```

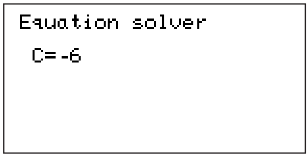
2. Press ENTER.
   The screen is changed to the variable input screen.
   The message, [Solver: Equation], shows the analysis method used by the solver.
   Unless otherwise specified, the solution is found by the equation method.

```
Solver:Equation
 A=0
 B=0
 C=0
 D=0
```

3. Next, input numeric values for known variables.
   The cursor pointer is located at "A". This allows you to input a value for A.
   Press 10 ENTER 3 ENTER ▼ (—) 5 ENTER to input values for variables except for C.

```
Solver:Equation
 A=10
 B=3
 C=0
 D=-5
```

4. To find the solution:
   Press [▲] to move the cursor to "C=" (after inputting numerical values, the cursor pointer is at "D").
   Press [2ndF] and [EXE] to display the answer screen shown to the right.

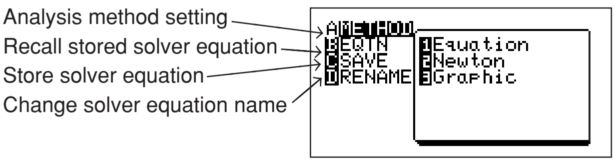



* After the solution has been found, press [CL] to return to the variable input screen. On this screen, you may change the numeric values in the variables and select another unknown variable to find the solution again.

* To edit the equation, press [CL] on the variable input screen to change the screen to the equation input screen, allowing you to correct or edit the previously input equation.

# 2. Selecting the Solution Analysis Method

- The calculator has three kinds of analysis methods that may be used to find the solution. They are equation, Newton, and graph methods.
- When the solution can be found by a simple algebraic equation, the equation method is normally used. The calculator automatically selects this method in the default setting (unless otherwise specified).
- If the solution cannot be found by the equation method, it automatically switches to the Newton method.
- To select the analysis method:
  Press [2ndF] [SOLVER] to enter the solver mode and press [2ndF] [SOLVER] again. The following menu will appear on the screen.




The following analysis methods are built into the menu, [A METHOD].

[1 Equation] : Solution is directly found by the equation method.
[2 Newton] : Solution is found by the Newton method.
[3 Graphic] : Solution is found by the graph method.

## (1) Newton's method

- This method is used to find the solution of a complex equation. For example, this method can obtain the real value of a square root by repeating calculations.
- To find the solution using this method, it is necessary to specify the initial value (START) and step value (STEP).
  The calculation is repeated until the difference between the right side and left side of the equation is within the allowable range.

**<Example>**

Use the equation "S = P (1 + I)$^N$" (S: Amount with interest added, P: Initial investment amount, I: Interest rate, N: Investment period) to calculate an interest rate necessary to get $15,000 after 5 years from an initial investment of $10,000.

1. Press [2ndF] [SOLVER] [CL] [CL]. Clears the previous equations.
2. Press [2ndF] [SOLVER] [A] [2]. Specifies the Newton analysis method.
3. To input the equation, follow these steps.
   Press [2ndF] [A-LOCK] S [=] P [ALPHA] [(] 1 [+] [ALPHA] [I] [)] [a$^b$] [ALPHA] N [▶].

```
S=P(1+I)^N _
```

4. Press [ENTER]. (The variable input screen will appear.)
5. To input each known value:
   Press 15000 [ENTER] 10000 [ENTER] [▼] 5 [ENTER].

```
Solver:Newton
 S=15000
 P=10000
 I=0
 N=5
```

6. Move the cursor to "I" and perform calculation.
   Press [▲] [2ndF] [EXE].
7. To input START and STEP values:
   0 [ENTER] .001 [ENTER]

```
Newton solver
START=0
STEP=.001
```

```
Newton solver
 I=.084471771
RIGHT=15000
LEFT =15000
L-R  =-.000000156
```

8. Press [2ndF] [EXE] to find the solution.
   As a result, I = 0.084471771 (≒ 8.45%) is obtained.
   Approximate values of the right (RIGHT=) and left (LEFT=) sides and the difference (L–R =) will appear on the screen, allowing you to check the error range.

- This method finds an approximate value of the solution, so that the difference between the right side and left side of the equation is 0.
- The value obtained by this method may include an error. As the difference between the right and left sides is small, a value close to the real value is obtained. (If the difference is large, the error is also large.)
  Therefore, when the difference between the right and left sides is large, a value close to the real value is not obtained.
- If this occurs, change the STEP and START values and recalculate the solution. (Press [CL] to return to the variable input screen.)
- Additionally, if a difference between the right and left sides exists, recalculate with the obtained value used as the START value to obtain a value closer to the real value.
- In above example, even if you had not set the Newton method for analysis, the calculation will be performed in the same manner as described in the equation method. That is, first the equation method attempts to find the solution. If the solution cannot be obtained, the method is automatically switched to the Newton method and the START and STEP value input screen will appear. Inputting numeric values automatically changes the analysis method to the Newton method.

## (2) Graph method

- In the graph method, the solution is found by plotting the right and left sides of the equation to get the intersection.
- Drawing the graph allows you to understand whether multiple solutions exist, whether the solution is an inconsequential line or asymptotical line, as well as its upper and lower limits.

- Additionally, this method can be used to plot the graph and find approximate values if the initial value is unknown when finding the solution by the Newton method.
- The start point (BEGIN) and end point (END) are input in this method, instead of START and STEP in the Newton method.
- When the solution is found, the cursor flashes at the intersection of the two graphs and the solution is displayed on the bottom of the screen.
- If the message, " No solution in window", is displayed on the screen, it shows that no solution was found in the specified range.
- If this occurs, press [CL] to return to the variable input screen and change the BEGIN and END values.
- To enlarge a part of the graph after the solution has been found, you may use the ZOOM Box function. (See CHAPTER 4 "9. Zoom Function" on page 100.)

**<Example>**

Find the time when the ball reaches a point 3 m high after it has been thrown straight up at an initial speed of 10 m/sec.

Applicable equation: $H = 0.5\ GT^2 + VT + D$

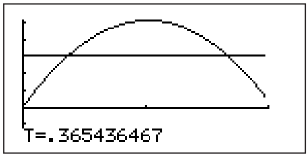
(H: Height, G: Acceleration due to gravity = -9.8 m/s$^2$, T: Time, V: Initial speed, D: Initial height)

1. Press [+-×÷] [2ndF] [SOLVER] [CL] [CL]. Clears the previous equation.
2. Press [2ndF] [SOLVER] [A] [3]. Selects the graphic mode.
   Input the equation.
3. Press [ALPHA] H [ALPHA] [=] 0.5 [ALPHA] G [ALPHA] T [$x^2$] [+] [ALPHA] V [ALPHA] T [+] [ALPHA] D [ENTER].

```
Solver:Graphic
 H=0
 G=0
 T=0
 V=0
 D=0
```

4. Input values for the known variables and calculate T.
   Press 3 [ENTER] [(—)] 9.8 [ENTER] [▼] 10 [ENTER] 0 [ENTER] [▲] [▲] [2ndF] and [EXE].
5. Set the range.
   Press 0 [ENTER] 2 [ENTER] [2ndF] [EXE].
6. As a result, T = 0.365436467 (≑ 0.37 sec.) is obtained.

```
Graphic solver
variable range
BEGIN=0
END=2
```




∗ If multiple solutions exist:
- When the first solution is obtained, the process is stopped. If other solutions exist, change the parameters to perform the process in a different range.
- It is possible to change the initial value (START) for the Newton method and the range (BEGIN and END) for the graph method, respectively.
- Additionally, if more than one intersection exists on the graph screen, the CALC function can be used.
- To find the second intersection in the above example, follow these steps.

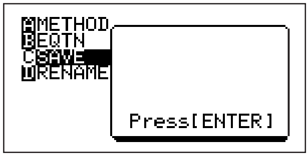
1. Press [2ndF] [CALC].
2. As a result, “T = 1.675379859 (≒ 1.68 sec.)” is obtained.

# 3. Registering an Equation

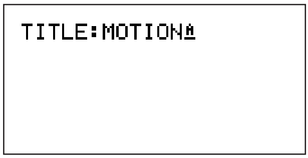
To register an equation, input the equation after entering the SOLVER mode or enter one of the screens after executing calculation.

- An equation which is frequently used can be registered using the following steps .
- Registration of solver equations is done while in the SOLVER mode.

1. Press [2ndF] [SOLVER] to display the solver menu.




2. Press [C] [ENTER] to select the registration mode (SAVE).




3. Input an equation name.
   The number of characters for the equation name is 8 or less.
   When in the SAVE mode, ALPHA LOCK is automatically placed so that letters may be entered without having to press [ALPHA].

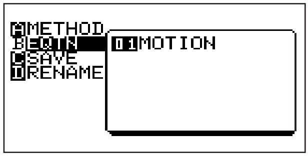
4. Press (ENTER) to register the equation.
- A maximum of 99 equations can be registered.
- The number of equations which may be registered varies depending on how much memory is currently free.

# 4. Calling Up the Solver Equation

- To call up the registered solver equation, follow these steps.

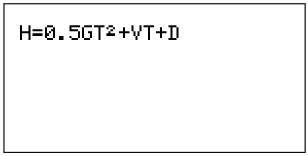
1. Press (2ndF) (SOLVER) to enter the solver mode.
2. Press (2ndF) (SOLVER) again to display the solver menu.
3. Press ( B ).

   The equation number and its name will appear on the screen.




4. Press ( 0 )( 1 ) (ENTER). (Input the equation number to call a desired solver equation.)

- After the equation has been called, enter values for known variables and move the cursor to the variable for which you wish to find the solution, and solve.

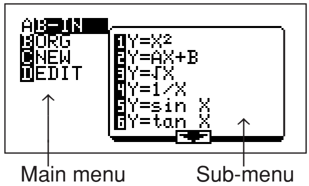


# 5. Renaming the Solver Equation

```
TITLE:MOTION
```

- To rename an equation which is already registered, select [D RENAME] in the solver menu. The equation number and name will appear on the right portion of the screen.
  Select the equation number for which you wish to change the name. (In this example, press 0 1 ENTER.)
- The cursor pointer will appear at the head of the name. Enter the new name.
- ALPHA LOCK is automatically turned on in this mode, so letters may be entered without having to press ALPHA.

# CHAPTER 10
# SLIDE SHOW FUNCTIONS




The calculator is equipped with two types of slide show functions:

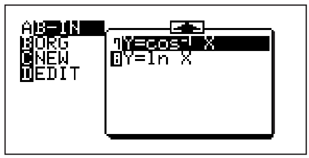
- **Built-in Slide Show.** You can redisplay stored function equations and graphs and coordinate relationship screens.
- **Creating an Original Slide Show.** You can create your own slide show screens and register them.

To enter the slide show screen, press [SLIDE SHOW].
The screen shown to the right will appear.
([A B - IN] is highlighted and options 1 to 6 will appear on the right portion of the screen.)
The main menu of the slide show has the following classifications.

A B-IN .... Used to call up the built-in slide show screen.
B ORG ... Used to call up the original slide show screen.
C NEW... Used to perform the default settings (registration of name) for the original slide screen.
D EDIT ... Used to edit the original slide show.

## 1. Built-in Slide Show

- The calculator has eight built-in equations. (On the above screen, equations 1 to 6 are displayed. Pressing [▶] [ALPHA] [▼] scrolls the screen to display equations number 7 and 8.)




* Pen-touch selection is also possible.

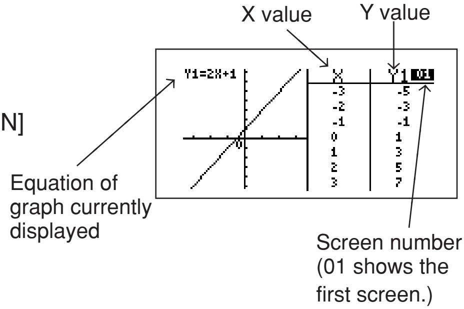
- This function is designed for read-only access. (After the screen has been displayed, press [▼] or [▲] to scroll up/down the screen.)
- It is impossible to edit and delete the slide show screen. (Only slide shows you have created yourself can be edited, changed, and deleted.)
- The slide show screen is designed to help understand the graph. The contents displayed on the screen may vary from the actual screen.
- The operations are explained with reference to the example.

**<Example>**

View the slide show screen for “Y = AX + B”:

1. Press [SLIDE SHOW]. Enters the slide show mode.
2. Press [ENTER] [▼] [ENTER]. Selects [A B-IN] and “2 Y = AX + B”.

   The first screen appears as shown on the right.




   Although equations are expressed using “Y=AX+B” when selecting, numbers are substituted for A and B in the actual screen.

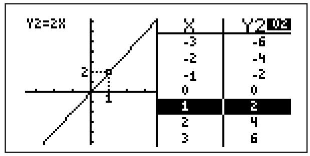
3. Scroll up the screen.

   The graph for “Y2 = 2X”, and X and Y2 values will appear on the screen.

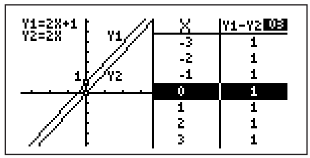
   As the values in the table are highlighted, the dotted line showing the coordinates on the graph and coordinate values are displayed.

   When the screen is further scrolled up, two graphs, screen 01 and screen 02, and the value of “Y1–Y2” are displayed, demonstrating the relationship between graphs Y1 and Y2. (That is, “Y1–Y2” is always 1.)

[▼]



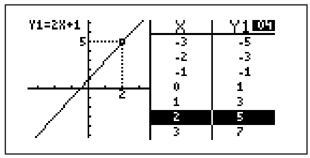

[▼]




   The Y coordinate corresponding to “X = 2” in graph Y1 is shown on screen 04.

* As shown above, the Y values corresponding to the X values (Y1, Y2, etc.) and the relationship between the graph and equation can be easily understood.

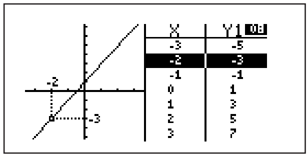
[▼]




[▼]
[▼]
⋮
[▼]

- The graph screen is sequentially scrolled up using the cursor key ([▼]). (To scroll down the screen, press [▲].)

- When [▼] is pressed sequentially, the slide show screen for “Y = AX + B” is stopped on the screen shown to the right.




- That is, the built-in graph for “Y = AX + B” is completed on the 8th screen. (At this time, use of [▼] is invalid but use of [▲] is valid.)

* The number of screens may vary depending on the selected equation. That is, not all equations are composed of 8 screens.

* To exit the slide show screen, press [2ndF] [QUIT] to return to the standard function calculation screen viewed immediately before starting the slide show.

# 2. Creating an Original Slide Show

The calculator provides a function which allows you to create your own slide show screens and register them.

- The number of screens which you can store may vary depending on the amount of free memory. (It is possible to register as many screens as the memory capacity allows. However, if you use up most of the memory for the slide show, this may affect other calculations.)
- A title can be put on the original slide show. (Only one title can be put on the slide show.)
- The flowchart for creating your original slide show is shown below.

| | |
|---|---|
| Enter the slide show creation mode. | : [SLIDE SHOW] [C] [ENTER] |
| Put a title on the slide show. | : Input a title. [ENTER] |
| Register screens. | : After creating an original slide show, press [2ndF] [CLIP] to store the original slide show. |

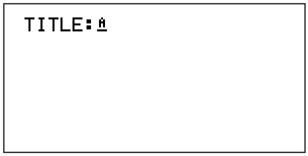
- The original slide show has no specific end mark. (When another slide show is created following the original slide show, the previous data is cleared and updated by the new slide show.)

Create an original slide show according to the example.

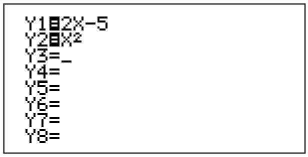
**<Example>**

Input “Y1 = 2X–5” and “Y2 = $X^2$”, and then store the equations, graph screen, table screen, and graph and table screen in sequential order. (Set to the X-Y coordinate system.)

1. Press [⊞⊟⊠⊡] [CL]. Clears the screen.
2. Press [SLIDE SHOW] [C] [ENTER].
   Selects the original slide show (new slide show) creation mode.
   Displays the title input screen shown to the right.



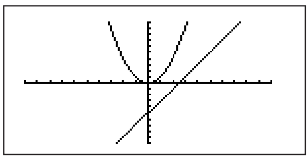

3. Input the title as “GRAPH”. (Up to 8 characters can be used for the title.)
   Press [ENTER].
   After the above steps have been completed, the preparations for the creation of the original slide show are completed. Thereafter, you may create and store screens to complete the original slide show. (A number from 01 is put on the screen every time it is created. The screen will be redisplayed from 01.)
4. Press [Y=] 2 [X/θ/T/n] [–] 5 [ENTER]. Inputs “2X–5” to Y1.
5. Press [X/θ/T/n] [$x^2$] [ENTER]. Inputs “$X^2$” to Y2.
   At this time, the screen shown to the right will appear.
   First, register this screen as screen number 1.



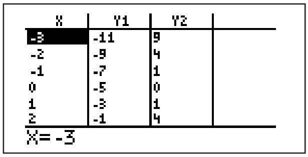

6. Press [2ndF] [CLIP].
   Registers the screen. (The screen shown to the right will appear for approximately 2 seconds, showing that the registration is completed. After the message disappears, the screen returns to the equation screen above.)


Shows the first screen.

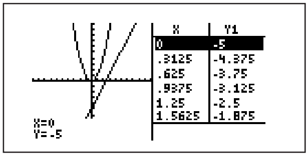
7. Press [GRAPH].
   Draws graphs for “Y1 = 2X – 5” and “Y2 = $X^2$”.
8. Press [2ndF] [CLIP].
   Register the graphs. (The message, “STORE SCREEN:02”, will appear instantaneously.)



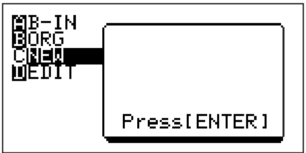
9. Press TABLE. Displays the table.
10. Press 2ndF CLIP. Registers the screen.
11. Press 2ndF SPLIT. Displays both the graph and table.
12. Press 2ndF CLIP. Registers the screen.




After the above steps have been performed, creation of the necessary screens is now completed.
Subsequently, normal operations can be performed unless 2ndF and CLIP are pressed.

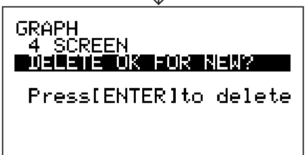



• When [C NEW] is selected after the original slide show has been created, the screen transition is as follows.




Press ENTER.

Displays the title of the original slide show and the number of screens.



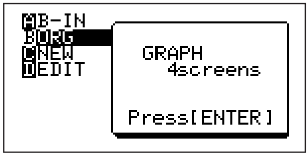

Press 2ndF QUIT to return to the standard function calculation screen.

Press ENTER.

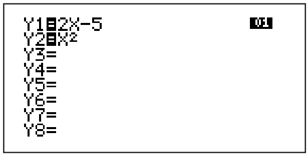
# 3. Viewing the Original Slide Show

To view the original slide show which was created previously, follow these steps.

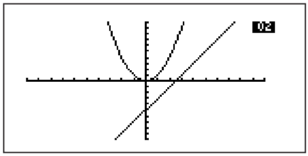
1. Press [SLIDE SHOW] [B]. Sets the slide show to the view mode.




2. Press [ENTER]. Displays the first screen.
   (The symbol, “01” is highlighted in the upper right corner of the screen.)

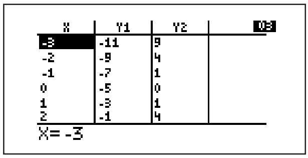



3. Press [▼].




4. Press [▼].

• To return to the previous screen, press [▲].



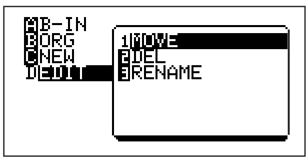

# 4. Editing the Original Slide Show

The registered slide show data can be sorted, and deleted, and the title can be renamed in the edit mode.

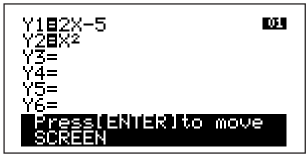
## (1) Changing the order of the screens (MOVE)

• To move the screen number 02 created in the graph to the last entry, follow these steps.

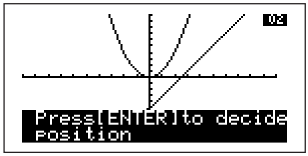
1. Press [SLIDE SHOW] [D] [▶].
   Selects the menu [1 MOVE] of [D EDIT].



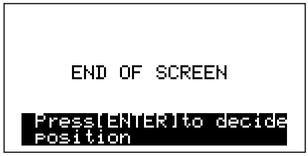
2. Press (ENTER).
   Displays the first screen of the original slide show.
   A message prompting you to select a screen to be moved will appear.




3. Press (▼) (ENTER).
   Calls up the second screen. Press (ENTER) to set it.
   The message on the bottom of the screen will be changed.

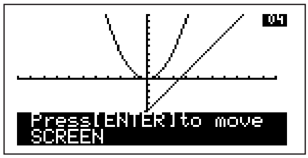



4. Press (▼) (▼) (▼).
   If the screen scroll overruns the final screen (number 04), the message shown to the right will appear on the screen.
   Since the MOVE command puts the desired screen before the currently displayed screen, this message appears on the screen.




5. Press (ENTER). Completes the screen movement.
   The final screen will appear after the screen movement is completed.

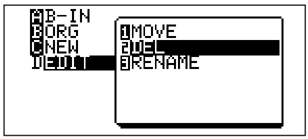
* Exit this mode by pressing (2ndF) (QUIT).



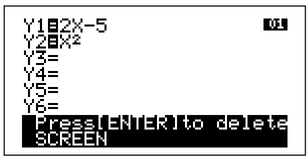

## (2) Deleting the registered screen (DEL)

To delete screen number 04, which has been moved in the previous step, follow these steps.

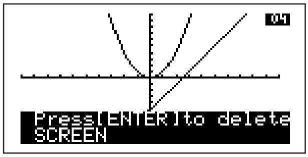
1. Press (SLIDE SHOW) (D) (▶) (▼).
   Selects menu [2 DEL] of [D EDIT].



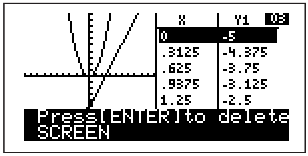

2. Press (ENTER).
   Displays the first screen of the original slide show.



3. Press [▼] [▼] [▼].
   Selects a screen which you wish to delete.




4. Press [ENTER]. Deletes the selected screen.
   The final screen (screen number 03) will appear at the same time when screen number 04 is deleted.

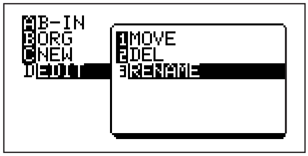



* Exit this mode by pressing [2ndF] [QUIT].

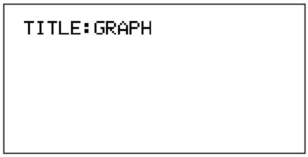
## (3) Renaming the registered title (RENAME)

To change the title, “GRAPH”, of the screen that was entered in the previous steps to “ORIGINAL”, follow these steps.

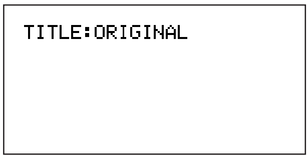
1. Press [SLIDE SHOW] [D] [▶] [▼] [▼].
   Selects menu [3 RENAME] of [D EDIT].



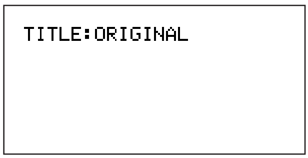

2. Press [ENTER]. Displays the title screen. The cursor flashes on the top line.




3. Inputs the new title, as “ORIGINAL”.




4. Press [ENTER]. Sets the new title.




* Exit this mode by pressing [2ndF] [QUIT].

# CHAPTER 11
# SHIFT/CHANGE FUNCTIONS

The calculator provides SHIFT and CHANGE functions:

- **SHIFT Function.** It automatically move the graph equation corresponding to the amout of movement.
- **CHANGE Function.** It automatically move the graph equation by changing the shape (slope) of the built-in graph.

- The graph is moved or changed by a step set on the graph axis.
- Eight typical graphs for SHIFT and six graphs for CHANGE function are built into the calculator.
- You may display a graph and equation on the same screen and easily view changes in the graph and equation.
- The graph locus which you have moved or changed can be temporarily stored.
- Equations built into the SHIFT and CHANGE functions are expressed only in the rectangular coordinate system, regardless of the current coordinate system.

## 1. SHIFT Function

The following shows the built-in equations, shift steps, and movable range applicable to the SHIFT function.
(For trigonometric functions, the same equation is stored in the degree, radian, and gradient modes based on the difference of the angle settings.
Depending on the angle settings, the equation is called up with an optimal range setting.)

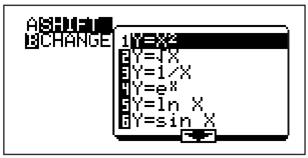
• The movable range of the graph is determined by the step. The shift function cannot be used beyond the range shown in the following table.

| Number | Equation | Movement step | Movable range |
|---|---|---|---|
| 1 | $Y=X^2$ | X : 1<br>Y : 1 | X=–5 to 5<br>Y=–3 to 3 |
| 2 | $Y=\sqrt{x}$ | X : 1<br>Y : 1 | X=–6 to 4<br>Y= –3 to 3 |
| 3 | Y=1/X | X : 1<br>Y : 1 | X=–4 to 6<br>Y=–4 to 2 |
| 4 | $Y=e^x$ | X : 1<br>Y : 1 | X=–5 to 5<br>Y=–4 to 2 |
| 5 | Y=In X | X : 1<br>Y : 1 | X=–4 to 6<br>Y=–3 to 3 |
| 6 | Y=sinX<br>(DEG) | X : 90<br>Y : 1 | X=–360 to 360<br>Y=–3 to 3 |
| | Y=sinX<br>(RAD) | X : 1.57<br>Y : 1 | X=–2π to 2π<br>Y=–3 to 3 |
| | Y=sinX<br>(GRAD) | X : 100<br>Y : 1 | X=–400 to 400<br>Y=–3 to 3 |
| 7 | Y=tanX<br>(DEG) | X : 45<br>Y : 1 | X=–180 to 180<br>Y=–3 to 3 |
| | Y=tanX<br>(RAD) | X : 0.785<br>Y : 1 | X=–π to π<br>Y=–3 to 3 |
| | Y=tanX<br>(GRAD) | X : 50<br>Y : 1 | X=–200 to 200<br>Y=–3 to 3 |
| 8 | Y= \| X \| | X : 1<br>Y : 1 | X=–5 to 5<br>Y=–3 to 3 |

**<Example>**

The SHIFT function is explained using the graph for $Y=X^2$.

1. Press [2ndF] [SHIFT/CHANGE] [▶]. (Touch [A SHIFT] and [1 $Y=X^2$] with the pen.) Sets the shift mode of "$Y=X^2$".

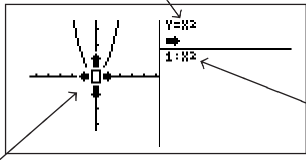



   (To select equations numbers 7 and 8 which are not displayed, touch [↓] with the pen or press [▶] [ALPHA] [▼] to scroll up the screen.)

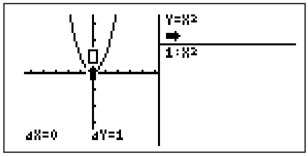
2. Press [1]. The first screen of the shift function shown below will appear.

Shows the graph equation before movement. (Solid line graph shown to the left)

Arrows showing the movable directions. (In this example, the arrows showing that the cursor can be moved in both the vertical and horizontal directions, are displayed at (0, 0).)

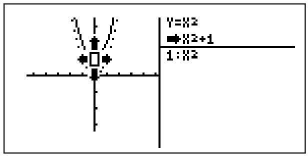



Shows the registered equation. (The first equation, “Y = X$^2$”, is automatically registered.)



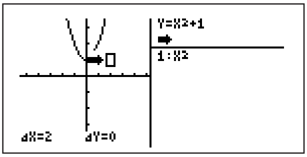

3. Press (▲). (When using the touch-pen, touch above this symbol “”.) Shows that the graph for “Y = X$^2$” is moved one scale unit (Y =1) upward.

* The cursor shows that the graph can be moved in the direction of “” (upward) from the start point (0, 0).
The ΔX and ΔY located at the bottom of the graph indicate the amount of movement of the X and Y axis.

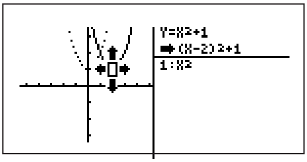



4. Press (ENTER).
When the movement direction and amount are accepted, press (ENTER) to set them. Since the original graph (Y = X$^2$) has been registered, the line type is changed from the solid line (—) to the dotted line (....) as the graph is moved, and both lines remain on the screen.
The upper right portion of the screen shows changes in the graph equation as the graph is moved. That is, “Y = X$^2$” is changed to “Y = X$^2$ + 1”. Additionally, the cursor can also be moved in both the vertical and horizontal directions.
The above operation shows that the graph for “Y = X$^2$” is changed to “Y = X$^2$ +1” and the screen waits for the next operation.

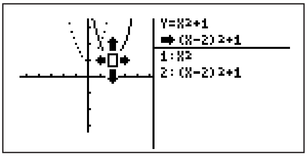
5. Press ▶ ▶. (When using the touch-pen, press a point slightly away from the right arrow "✥".) Moves the graph two scales to the right (in the + X direction). At this time, the equation "$Y = X^2 + 1$" overwrites "$Y = X^2$", and the area where "$Y = X^2 + 1$" is displayed becomes blank. The graph for "$Y = X^2$", displayed by a dotted line on the graph screen, disappears. This means that the graph can be moved based on the newly moved equation "$Y = X^2 + 1$". (The graph displayed by a dotted line is the previous graph before starting movement. This does not relate to saving the equation.)



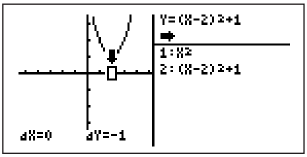

6. Press ENTER. The screen shows that the equation is changed from "$Y = X^2 + 1$" to "$Y = (X–2)^2 + 1$" as the graph is moved.
(At the same time, the graph for "$Y=X^2 + 1$" is changed from the solid line to the dotted line.)



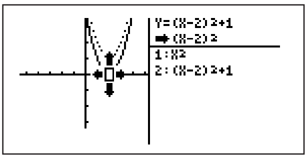

7. Press ENTER. Saves the equation (graph) "$Y= (X–2)^2 + 1$".
The saved equation "$(X–2)^2 + 1$" is added under "$Y=X^2$" on the right portion of the screen. (Up to ten equations, 1 to 9, and 0, including the base equation ($Y = X^2$) can be saved.)



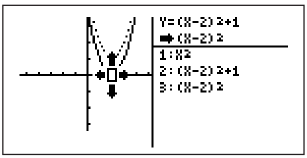

8. Press ▼. Further moves the graph one scale unit downward.




9. Press ENTER. The graph for "$Y = (X–2)^2 +1$" is changed from the solid line to the dotted line.

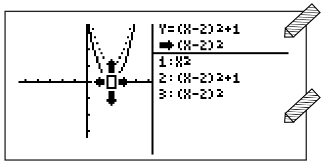



10. Press ENTER. Saves the graph for "$Y = (X–2)^2$".
- The above description indicates how the equation changes as the graph is moved in a desired direction.



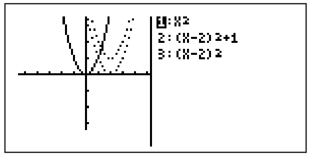
Next, to draw graphs from the saved equations, follow these steps.

• There are the following two methods to enter the graph regeneration screen.
① Touch the right portion of the screen with the pen where the equations are displayed.
② Press ALPHA ▶.

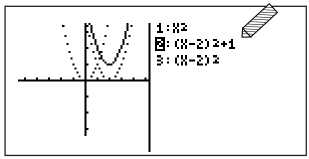


Touch any part on the right portion of the screen.

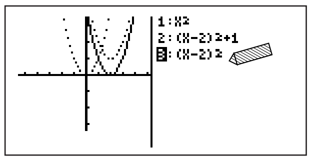
- The screen shown to the right will appear and all saved equations will be displayed on the right portion of the screen.




- The cursor is located at [1: $X^2$], and the graph corresponding to that equation is displayed by a solid line. Other graphs are displayed by dotted lines.
- Touch a part where [2: $(X–2)^2+1$] is displayed or press ▼ to move the cursor to “2”. At the same time, the graph corresponding to the selected equation is changed from the dotted line to the solid line, and other graphs are displayed by dotted lines.

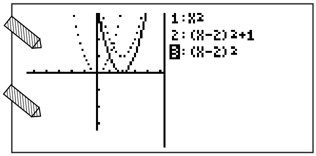



- Accordingly, when the equation [3: $(X–2)^2$] is selected, the graph for that equation is changed to the solid line and other graphs are displayed by dotted lines, enabling you to view changes in equations and graphs.

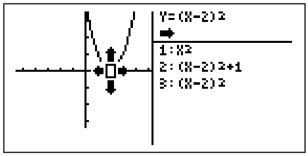


- To return to the graph movement mode, follow one of these two methods.
  On the screen shown to the right,

① Touch any part on the left portion of the screen where the graph is displayed with the pen.




② Press ALPHA ◀.
Either of the above operations makes it possible to enter the graph movement screen shown to the right, allowing you to move the graph.

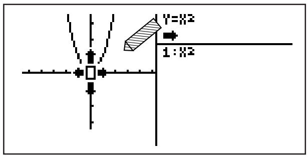



* In the above example, since the graph for [3: $(X–2)^2$] has been selected, that equation becomes a base equation immediately after the graph movement screen is displayed. (Therefore, if the equation [2: $(X–2)^2 + 1$] has been selected, that equation becomes a base equation.)

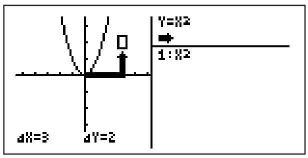
* Note that the above operation clears equations not saved on the previous graph movement screen.

**Supplementary explanation:**

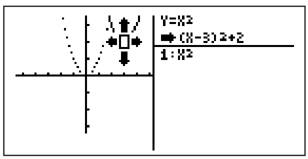
1. To quickly move the graph, touch a point with the pen to where you wish to move the graph, as shown to the right. (Or keep the cursor movement key pressed until the desired ΔX and ΔY are obtained. In the example to the right, press ▶ ▶ ▶ ▲ ▲.)




2. "□" showing the destination point will appear on the screen and an arrow mark located at that point is enlarged.



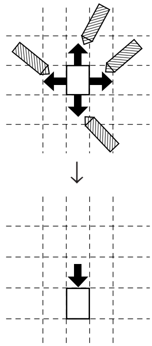

3. Press ENTER.



## Movement range using the touch-pen:

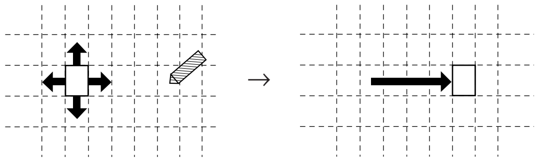
- A cursor having four arrow marks shows that it can be used in both the horizontal and vertical directions.
- As shown in the above figure, an area where the pen can be touched is not in units of dots, but in units of grids containing of 6 × 8 dots.

* The dot structure of the grid is different from that of "□" to be displayed.

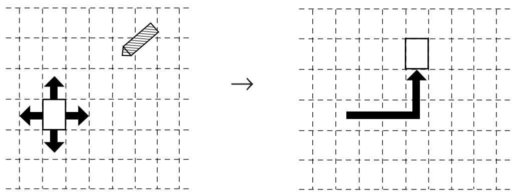


(When touching the down arrow.)

- Therefore, to move the graph one scale unit, touch the arrow as shown in the above example.
- To move the graph two scales or more in parallel, touch a part away from the arrow.



- The same procedures are applied to quick movement in the X- and Y- directions .



## To return from the SHIFT function to the previous screen:

- Press [CL] to return to the screen which appears immediately after a desired equation has been selected by pressing [2ndF], [SHIFT/CHANGE], [A SHIFT ], and equation.
- Press [2ndF] [QUIT] to return to the standard function calculation screen.
- Note that the above key operations clear the moved or saved equations/graphs. (The built-in equations are not cleared.)

# 2. CHANGE Function

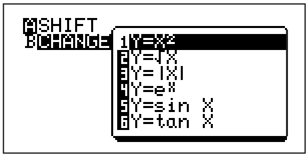
The SHIFT function previously described allows you to move the graph and view the relationship between the moved graph and its equation.
The CHANGE function shows the relationship between the graph and equation by changing the shape of the graph.
For example, using this function, you may view changes such as “$Y = 2X^2$” and “$Y = 3X^2$” based on “$Y = X^2$”. Selection of the screen and equation are done using procedures similar to those used in the SHIFT function.
The following shows the built-in equations, change steps, and movable range applicable to the change function.
(In the same manner as described in the SHIFT function, the trigonometric functions for different angles are also included.)

| Number | Equation | Movement step | Movable range |
|---|---|---|---|
| 1 | $Y=X^2$ | X : 1<br>Y : 1 | Y=–3 to 3 |
| 2 | $Y=\sqrt{x}$ | X : 1<br>Y : 1 | Y=–3 to 3 |
| 3 | Y= \| X \| | X : 1<br>Y : 1 | Y=–3 to 3 |
| 4 | $Y=e^x$ | X : 1<br>Y : 2.718 | Y=–3 to 3 |
| 5 | Y=sinX<br>(DEG)<br>Y=sinX<br>(RAD)<br>Y=sinX<br>(GRAD) | X : 90<br>Y : 1<br>X : 1.57<br>Y : 1<br>X : 100<br>Y : 1 | Y=–3 to 3<br><br>Y=–3 to 3<br><br>Y=–3 to 3 |
| 6 | Y=tanX<br>(DEG)<br>Y=tanX<br>(RAD)<br>Y=tanX<br>(GRAD) | X : 45<br>Y : 1<br>X : 0.785<br>Y : 1<br>X : 50<br>Y : 1 | Y=–3 to 3<br><br>Y=–3 to 3<br><br>Y=–3 to 3 |

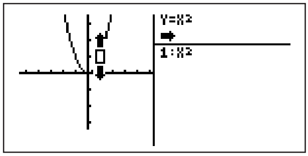
**<Example>**

The CHANGE function is explained using the graph for “Y = $X^2$”, also used in the SHIFT function.

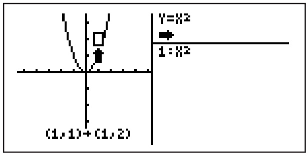
1. Press 2ndF SHIFT/CHANGE B ▶. (Touch [B CHANGE] and [Y= $X^2$] with the pen.) Sets the CHANGE mode of “Y = $X^2$”.



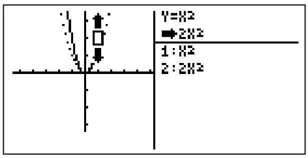

2. Press ENTER. Sets the CHANGE mode. The screen shown to the right will appear.
   The cursor with a shape of “↕”, different from that in the SHIFT screen, will appear on the graph for “Y = $X^2$”.
   This indicates the directions in which the graph can be changed (only upward and downward in this example). The same rule is applied to other equations.




3. Press ▲. (Touch the upper arrow of “↕” with the pen). The cursor frame “□” moves upward and an arrow will appear toward the cursor.
   Numeric values displayed on the bottom of the screen show changes in the graph based on changes in the coordinates.
   (The example shown to the right means that you wish to change the graph for “Y = $X^2$”, passing through the coordinates (1, 1), to the graph passing through (1, 2).)

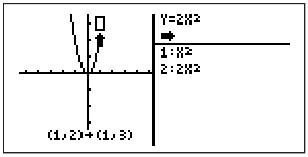



4. Press ENTER. Sets the moved graph.
   When setting the moved graph, the moved graph is displayed by a solid line, and the cursor is also moved to the graph after it has been changed.
   The expression showing that the equation has changed from “Y = $X^2$” to “Y = $2X^2$” will appear on the right portion of the screen.

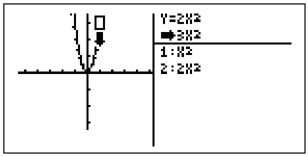



5. Press ENTER. Stores the equation “Y = $2X^2$”.

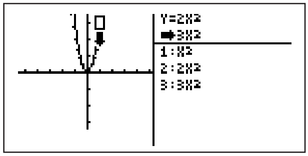
6. Press (▲). (Touch the upper arrow of "↕" with the pen.) The graph for "Y = 2X²" is further changed, as shown to the right.




7. Press (ENTER). Sets the moved graph.
   In the same manner as described in the SHIFT function, the previous graph is displayed by the dotted line and the currently selected graph is displayed by the solid line.




8. Press (ENTER). Stores the equation "Y = 3X²".

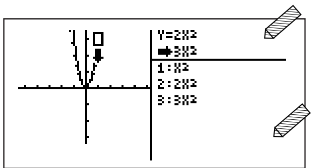



## Generating the graph from the saved equations:

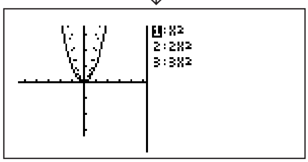
As described in the SHIFT function, there are the following two methods to enter the graph generation screen.

① Touch the right portion of the screen with the pen.

② Press (ALPHA) (▶).




Touch with the pen or press (ALPHA) (▶).




The graph generation screen shown to the right will appear.

Operations and the screen display are the same as those described in the SHIFT function.

- To return from the graph generation screen to the change screen, touch the left portion (graph screen) of the screen or press (ALPHA) (◀).

**To return from the CHANGE function to the previous screen:**

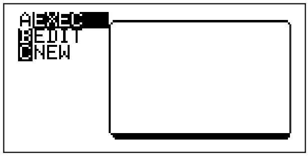
- Press (CL) to return to the screen which appears immediately after a desired equation has been selected by pressing (2ndF), (SHIFT/CHANGE), [B CHANGE], and equation.
- Press (2ndF) (QUIT) to return to the standard function calculation screen.
- Note that the above key operations clear the moved or saved equations/graphs. (The built-in equations are not cleared.)

# CHAPTER 12
# PROGRAMMING FUNCTION

- The calculator is equipped with a PROGRAM function.
- Programming makes the automatic processing of both simple and complex calculations possible any number of times.
- In addition to special functions, almost all ordinary functions can be used in programming.
- Complex numbers cannot be used in programming.

## 1. Creating a New Program

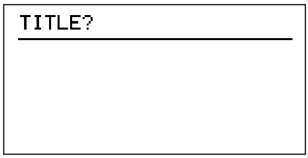
- The following is the procedure used to create a new program.




1. Press 2ndF PRGM to display the programming menu shown to the right.

* The titles of any existing programs are displayed on the right side of the screen.

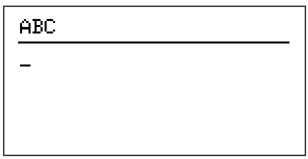
[A EXEC] - The program execution menu
[B EDIT] - The program edit menu
[C NEW] - The new program menu




2. Press C ENTER to select the new program menu. A program title input screen like that shown to the right will be displayed. First, input the title. (Titles can be up to 8 digits in length, and can include both letters and numerals.)

3. Input the program title (ex. ABC), then press ENTER.

4. The cursor pointer will move past the line under the program title and downward to the program input screen.




5. Input the program. In addition to standard functions, special programming functions from the programming function menu can also be used by pressing 2ndF PRGM again while in the programming mode.

# 2. Programming

- This instruction manual contains no explanations of necessary knowledge and concepts required for programming.
- Program input methods, commands and rules are explained assuming that the programmer has a certain degree of programming experience (BASIC, FORTRAN, etc.).
- The concepts of the programming language used by this calculator are basically the same as those of many other programming languages.
- The following commands are the minimum required for use in computer and calculator programs.
  - Input
  - Various branches
  - Loop
  - Calculation
  - Output

- This calculator is equipped with the commands necessary for inputting these basic elements into programs.
- Please refer to “Programming Commands” below for the available commands.
- Programming is also possible without using these commands.

# 3. Program Input and Edit

One becomes accustomed to inputting programs through actual practice. The following are descriptions of functions that are convenient for programming.

- Press [2ndF], [PRGM], [B], and the program Number to enter the program edit mode.
- To add an additional line to a program, first input [2ndF] [INS] to enter the insert mode to prevent overwriting the program by mistake.
- Letters can be entered into a program by using [ALPHA] before each character. To input letters into a program continuously, input [2ndF] [A-LOCK]. After that, it is no longer necessary to input [ALPHA] before each character. Press [ALPHA] to release continuous input status.
- Uppercase characters are input in the alpha mode. (Lowercase character input is not possible with the EL-9650.)

- Except for special cases, only one command (functions that can be input from the menu using 2ndF PRGM) can be input on each line.
- A maximum of 160 characters can be entered per line in a program. All commands are treated as a single character, regardless of the character length.
  When a line exceeds the width of the screen, the display will shift to the left (the line will not break at the right edge of the screen).
- Character strings displayed by the print command during program execution will break at the edge of the screen.
- During input and editing, lines will not be stored to memory until ▼, ▲ or ENTER is pressed. Thus, press ▼, ▲, or ENTER to store the input or editing contents and shift the cursor to the next line. If 2ndF QUIT are pressed, the status before input or editing will return.
- Blank lines (lines not containing a command, character, space, etc.) input during program editing are ignored during execution.
- Press CL to delete one line of a program.
  Press DEL or BS to correct text and command errors.
- Press 2ndF OPTION, and use the [C DEL] menu to delete an entire program.
- Use 2ndF PRGM to enter the program mode and then use 2ndF PRGM H to copy a program line to another location.
- To change a program name, use the cursor keys to shift the cursor to the program name and then input the new name. Use ALPHA when inputting each character.
  When the program name change has been completed, press ENTER or ▼ to return to program editing.
  If 2ndF QUIT is pressed instead of ENTER or ▼, the program name will not be changed.

# 4. Variables

- Uppercase letters and θ are used to express variables. Variables indicate calculator memory spaces (ex. a “C” in a program indicates the C memory space of the calculator). When that variable is used, then the contents of that memory space will be accessed. Variables can also be transferred from one program to another. The results of a program can also be stored and used in another mode.
- Pressing ENTER after the execution of a program is completed will re-execute that program. At such times, inputting any variables will again become necessary. If the value is the same as that of the previous variable, then just press ENTER.

Typical uses of variables in a program:

① 5 ⇒ X (5 [STO] [ALPHA] [X]): This program line substitutes the value 5 for the variable X. ("5" is stored in the X memory space.)

② MX + B ⇒ Y ([2ndF] [A-LOCK] [M] [X] [ALPHA] [+] [ALPHA] [B] [STO] [ALPHA] [Y]): This program line substitutes the value "(M × X) + B" for Y. The value of X is entered from memory.

**<Example 1>**

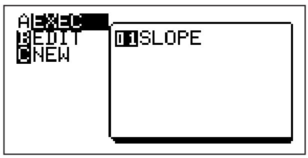
Try programming this equation. (Use the program name "SLOPE".)

| Program contents | Key operation |
|---|---|
| SLOPE | Press [+−×÷] [2ndF] [PRGM] [C] [ENTER] to enter the programming mode.<br>Press [S] [L] [O] [P] [E] [ENTER] to input the title. |
| Input M | [2ndF] [PRGM] [A] [3] [ALPHA] [M] [ENTER] |
| Input B | [2ndF] [PRGM] [A] [3] [ALPHA] [B] [ENTER] |
| MX+B⇒Y | [2ndF] [A-LOCK] [M] [X] [ALPHA] [+] [ALPHA] [B] [STO] [ALPHA] [Y] [ENTER] |
| Print "Y | [2ndF] [PRGM] [A] [1] [2ndF] [PRGM] [A] [2] [ALPHA] [Y] [ENTER] |
| Print Y | [2ndF] [PRGM] [A] [1] [ALPHA] [Y] [▼]<br>Press [2ndF] [QUIT] to end the program. |

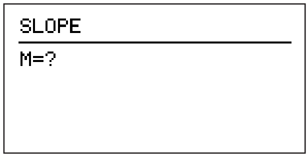
* Input: this command requests the input of a variable.
Print: this command displays the value of the variable on the screen.

- Execute the program.

1. Press [2ndF] [PRGM] [A] to search for the program name "SLOPE".
2. Press [0] [1] when at address 01, as shown to the right.

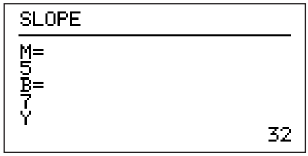


3. First, the value of the variable M is opened.

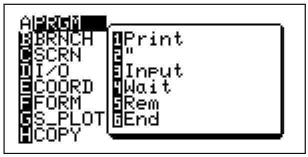



4. Press 5 ENTER next to open the value of B.

5. Press 7 ENTER to perform the calculation using the value of X stored to the X memory space and determine the value of Y.




# 5. Programming Commands




- The following explains the commands used for programming.
- The programming commands are displayed by pressing 2ndF PRGM in the program mode.
- The programming commands are shown in 8 main menus and their sub-menus.
- All of the programming commands can be used in the program mode.

* The input of ordinary functions by keying in or from the MATH menu, etc., is not explained here but almost all of these functions can be used in programs.

## (1) A PRGM menu

Press 2ndF PRGM A to select [A PRGM] and display the menu as described above.

**[1 Print]**

1. The value of the variable is displayed on the screen.
   The display format is determined by the SET UP menu settings.
   Entry: Print variable

**<Example>**

Print A      * "A" indicates the memory space
Print mat C
Print L1

2. Specified character strings following a quotation mark (”) will be displayed on the screen.
   The number of characters that can be input on one line is 160 (the actual number of characters that can be input, excluding commands, is 158).
   Entry 2: Print ” character string

**<Example>**

Print ” HELLO
Print ” PROGRAM

**[2 ”]**

Specifies a character string.
Characters input after this are considered to be a character string and will be displayed on the screen. (Used as a pair with other commands.)
Entry: command ” character string

**<Example>**

Print ”AB

**[3 Input]**

Interrupts program execution, displays “VARIABLE NAME = ?” on the screen and requests input of the value of the variable.
Entry: Input variable

**<Example>**

Input A
Input L1
Input mat A (1, 1)

**[4 Wait]**

Interrupts execution of the program for the number of seconds specified by the numerical value.

- The program will be re-executed if any key is pressed during this time.
- Convenient for displaying intermediate results and other information.
- Interrupt values of up to 255 can be specified with numerical values.
- If a numerical value is not specified, program execution will be interrupted until a key is pressed.

- The symbol will blink in the upper right corner of the screen while program execution is interrupted.

Entry: Wait numerical value

**<Example>**

Wait 10

**[5 Rem]**

Inserts comments into a program.

- This line has no affect on program execution. Such comments are not displayed on the screen, even during program execution.
- Comments are valuable aids for understanding a program, but do occupy memory space.

Entry: Rem optional character string

**[6 End]**

Indicates the end of a program.

- The End command is not necessary to end a program when the actual end is reached.
- The End command does not necessarily have to be used at the end of a program. Multiple End commands may be used. (Ex. When a program branches, the End command can be used to end execution at the branch destinations.)

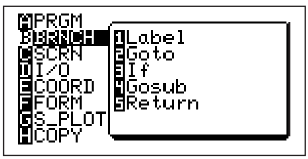
Entry: End

## (2) B BRNCH menu

Press 2ndF PRGM B to select [B BRNCH] and display the menu, as shown to the right.

**[1 Label]**

Used to specify branch destinations for Goto, etc.




- A label can only be used once within the same program.
- Labels can be up to 10 characters in length.
- Up to 50 labels can be used in one program.

Entry: Label character string

**<Example>**

Label LOOP

**[2 Goto]**

To shift program execution to a label (character string).

Entry: Goto character string

**<Example>**

Goto LOOP

**[3 If]**

Specifies conditional branches.

- Conditional branches start with the If command and are followed by the condition statement and the branch destination when the condition is satisfied.
- Only the Goto command can be used following an “If” command.
- A space can be entered before the Goto command to make the program easier to read.

Entry: If condition statement Goto character string

**<Example>**

If A = 1 Goto LOOP (If A = 1, then execution shifts to the Label LOOP. If A is not equal to 1, the next program line is executed.)

**[4 Gosub]**

Shifts program execution to the sub routine starting with Label <character string>.

- The Gosub character string must be the same as the character string of the Label indicating the start of the sub routine.
- Return is necessary at the end of the sub routine. When the Return statement is executed, program execution shifts to the next command after the Gosub statement.
- Up to 10 sub routines can be nested, i.e. 10 Gosub commands may be entered before a Return command is required.

Entry: Gosub character string

**<Example>**

Gosub PART 1

**[5 Return]**

Ends the sub routine and shifts the program execution to the next line after the Gosub statement that specified the jump to the sub routine.

Entry: Return

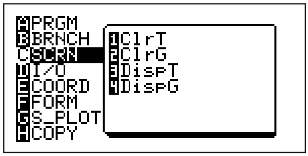
## (3) C SCRN menu

Press 2ndF PRGM C to display the menu selected with [C SCRN] on the screen, as shown to the right.

**[1 ClrT]**

Clears the program text screen without influencing the plotted graph. The program text screen is displayed.

Entry: ClrT




**[2 ClrG]**

Clears the graph screen without influencing the characters being displayed.

- The graph screen is displayed.
- After the graph screen is cleared, the specified graph statement is drawn.

Entry: ClrG

**[3 DispT]**

Displays the program text screen.

Entry: DispT

**[4 DispG]**

Displays the graph screen.

Entry: DispG

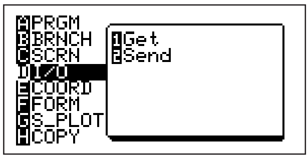
## (4) D I/O menu

Press 2ndF PRGM D to display the menu screen selected with [D I/O].

**[1 Get]**

Receives data from externally connected devices.

Entry: Get variable




**<Example>**

Get A

Get L5

Get mat B

**[2  Send]**

Sends data to externally connected devices.

Entry: Send variable

**<Example>**

Send C

Send L2

Send mat D

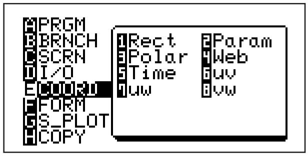
## (5) E  COORD menu

Press 2ndF PRGM E to display the screen selected with [E  COORD], as shown to the right.

**[1  Rect]**

Sets the graph coordinates as X and Y coordinates.

Entry: Rect




**[2  Param]**

Sets the graph coordinates as parametric coordinates.

Entry: Param

**[3  Polar]**

Sets the graph coordinates as polar coordinates.

Entry: Polar

**[4 Web]**

Sets the graph coordinates as axes in numerical string graphs.

- u(*n*-1) is set as the X axis
- u(*n*) is set as the Y axis

Entry: Web

**[5  Time]**

Sets the graph coordinates as axes in numerical string graphs.

- *n* is set as the X axis
- u(*n*) v(*n*) w(*n*) is set as the Y axis

Entry: Time

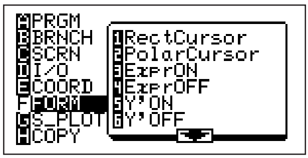
**[6 uv]**
Sets the graph coordinates as the axes of numerical string graphs.
- u(*n*) is set as the X axis
- u(v) is set as the Y axis
Entry : uv

**[7 uw]**
Sets the graph coordinates as the axes of numerical string graphs.
- Sets u(*n*) as the X axis.
- Sets w(*n*) as the Y axis.
Entry: uw

**[8 vw]**
Sets the graph coordinates as the axes of numerical string graphs.
- Sets v(*n*) as the X axis.
- Sets w(*n*) as the Y axis.
Entry: vw

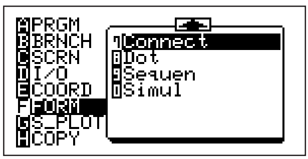
## (6) F FORM memu

Press 2ndF PRGM F to display the menu selected with [F FORM].
[F FORM] has many sub-menu items which cannot be displayed on one screen. Press ▶ ALPHA ▼ to view the next page.
* FORM is the menu that specifies the graph format to be used in a program.




**[1 Rect Cursor]** Sets the graph coordinate display format to X - Y axes.
Entry: Rect Cursor

**[2 Polar Cursor]** Sets the graph coordinate display format to polar coordinates.
Entry: Polar Cursor




**[3 Expr ON]** Sets the mode in which the graph equation is displayed on the graph screen.
Entry: Expr ON

**[4  Expr OFF]** Sets the mode in which the graph equation is not displayed on the graph screen.
Entry: Expr OFF

**[5  Y' ON]** Sets the mode in which the derived function (Y') is displayed on the graph screen.
Entry: Y' ON

**[6  Y' OFF]** Sets the mode in which the derived function (Y') is not displayed on the graph screen.
Entry: Y' OFF

**[7  Connect]** Sets the mode in which graphs are drawn using connected lines.
Entry: Connect

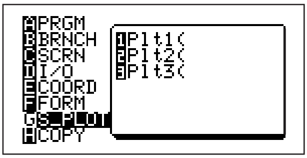
**[8  Dot]** Sets the mode in which graphs are drawn using dots.
Entry: Dot

**[9  Sequen]** Sets graph drawing to the sequential graph mode.
Entry: Sequen

**[0  Simul]** Sets graph drawing to the simultaneous graph mode.
Entry: Simul

## (7) G  S_PLOT menu

Press 2ndF PRGM G to display the menu selected with [G  S_PLOT].
The [G  S_PLOT] menu specifies locations where statistical data are graphed.




**[1  Plt 1(]** (Specifies that a statistical graph be drawn in plot 1.)

**[2  Plt 2(]** (Specifies that a statistical graph be drawn in plot 2.)

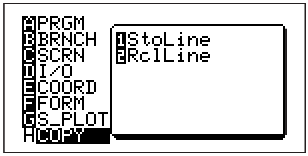
**[3 Plt 3(]** (Specifies that a statistical graph be drawn in plot 3.)
Entry: Plt1 (Type, Xlist, Ylist, Freq)

**<Example>**

Plt1 (Hist, L1, L2)
Plt2 (Scattr □, L3, L4)
Plt3 (xyLine+, L5, L6, L7)

## (8) H COPY menu

Press [2ndF] [PRGM] [H] to display the menu selected with [H COPY], as shown to the right.




**[1 Sto Line]**

Copies one line of the program.

- Used when it is desired to use the same contents or the same line more than once.
- Shift the cursor pointer to the line to be copied, select Sto Line, and press [ENTER] to store the line.
- Only one line can be stored to memory.

Entry: Sto Line

**[2 Rcl Line]**

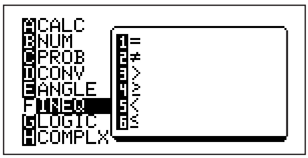
Calls out and transfers to the screen the program statement stored with Sto Line.

- To call out a statement to the screen, shift the cursor pointer to the line to be placed, then select Rcl Line and press [ENTER] to call out the stored program statement.
- This menu entry is used in combination with Sto Line.
  Entry: Rcl Line

# 6. Other Functions Often Used in Programs

## (1) Inequalities

Inequalities are located in the [MATH] [F] menu, as shown to the right.




- Consists of a condition statement together with If and Goto.
- Inequalities are the basis for constructing conditional branches and loops in a program.
- The following types of inequalities are used:

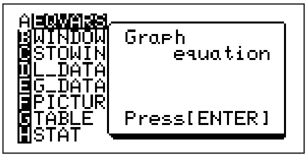
[MATH] [F] [1] " = " Equal to

| | | | | |
|---|---|---|---|---|
| MATH | F | 2 | " ≠ " | Not equal to |
| MATH | F | 3 | " > " | Greater than |
| MATH | F | 4 | " ≥ " | Equal to or greater than |
| MATH | F | 5 | " < " | Less than |
| MATH | F | 6 | " ≤ " | Equal to or less than |

**<Example>**
If X < 0 Goto NEG (If X is less than 0, then jump to "NEG".)
If Z = 3 Goto LOOP (If Z equals 3, then jump to "LOOP".)

## (2) Graphing functions

- Functions that control the graph screen can be selected from the VARS menu.
- Press VARS to display the VARS menu (shown to the right).




  [A EQVARS] Specifies the graph equation (Y1 to Y9,and Y0, X1T•Y1T to X6T•Y6T, R1 to R6).
  [B WINDOW] Specifies the functions that set the graph display screen size (Xmin, Ymax, Tstep, etc.).
  [C STOWIN] Specifies the zoom setting value (Zm_Xmin, Zm_Ymax, etc.).
  [D L_DATA] Specifies list data (L_Data1 to L_Data9, and L_Data0).
  [E G_DATA] Specifies the graph data (G_Data1 to G_Data9, and G_Data0).
  [F PICTUR] Specifies picture data (Pict1 to Pict9, and Pict0).
  [G TABLE] Specifies table setting values (Table start, Table Step, Table List).
  [H STAT] Specifies statistics, functions ( $\bar{x}$ , Σx, $\bar{y}$ … ), regression expressions, points and statistical verification functions.
- The commands and functions in the VARS menu can be displayed on the screen. Current setting data can also be reset.
- The results of arithmetic functions can also be displayed.
- The ZOOM command is selected directly from the ZOOM menu. Names of some ZOOM commands change when inserted into programs. These are [A ZOOM], [C POWER], [D EXP], [E TRIG], and [F HYP] of the ZOOM menu.
  "Zm_" is automatically added to each of these functions when inserted into programs.

<**Example**> Zm_Auto, Zm_$x^2$, Zm_sin, etc.

- Always enter the argument for functions requiring an argument at the end of the command, such as the CALC function ( 2ndF CALC ). Error will be returned for commands not accompanied by an argument.

<**Example**> Value 5

**<Example>**

Set Xmin = –3, Xmax = 10, Xscl = 1, Ymin=–5, Ymax = 5, Yscl = 1 in the WINDOW screen.

Use [STO] to input the settings.

| Expression | Operational sequence |
|---|---|
| -3 ⇒ Xmin | [(–)] 3 [STO] [VARS] [B] [ENTER] [A] [1] [ENTER] |
| 10 ⇒ Xmax | 10 [STO] [VARS] [B] [ENTER] [A] [2] [ENTER] |
| 1 ⇒ Xscl | 1 [STO] [VARS] [B] [ENTER] [A] [3] [ENTER] |
| -5 ⇒ Ymin | [(–)] 5 [STO] [VARS] [B] [ENTER] [A] [4] [ENTER] |
| 5 ⇒ Ymax | 5 [STO] [VARS] [B] [ENTER] [A] [5] [ENTER] |
| 1 ⇒ Yscl | 1 [STO] [VARS] [B] [ENTER] [A] [6] [ENTER] |

* Operation to input a function equation (for example, $x^2 + 2$) to the graphic equation “Y1” is also made using [STO] in the same manner as described above.
“$X^2 + 2$” ⇒ Y1: [2ndF] [PRGM] [A] [2] [X/θ/T/n] [$x^2$] [+] 2 [2ndF] [PRGM] [A] [2] [STO] [VARS] [A] [ENTER] [A] [1]

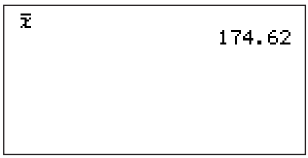
**<Example>**

The following data are included in list L1.

L1: 165, 182.5, 173.8, 166.5, 185.3

A one-variable statistical data calculation was executed based on this data.
After returning to the normal function calculation screen, average values can be viewed by using the following procedure.

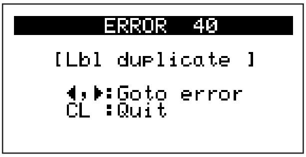
- Press [VARS] [H] [ENTER] [A] [0] [2] to display “$\bar{x}$” on the screen.
- Press [ENTER] to call out the average value of X as determined in the previous calculation.




- In this way, the contents of an immediately preceding statistical calculation can be stored as statistical values.
- These contents remain until the next statistical calculation is executed, even if the power is turned off.
- The same is true even for regression calculations and verification calculations.

# 7. Error Messages

- When a program is input, it is necessary to check the program for errors (debug the program).
- If a problem is found in a program, error messages will be displayed to facilitate debugging.
- For example, the following message will be displayed if the same label is used 2 times or more in the same program.




- Press ◄ or ► to display the line in which the error is located or press CL to return to the normal function calculation screen.
- Program execution can be interrupted anytime by pressing ON. (Convenient when a program has entered an infinite loop.) Press ◄ or ► at this time to display the cursor executed last.
- Refer to Appendix “3. Error Codes and Error Messages” on page 270 concerning error messages.

# 8. Sample Program

- Try executing the sample program to become accustomed to programming.
- Either input a command after pressing 2ndF PRGM or select another menu.
- In the following sample program, commands have been underlined to distinguish them from variables.

## (1) Conversion of temperatures from Celsius to Fahrenheit

This program converts temperatures in Celsius to Fahrenheit and vice versa.

- The file name is “CONVERT”.
  (The following line numbers are unrelated to the program. They are used merely to identify lines.

## Input:

| Program | Key operation |
|---|---|
| | 2ndF PRGM C ENTER |
| CONVERT | C O N V E R T ENTER |
| 1. Label START | 2ndF PRGM B 1 2ndF A-LOCK S T A R T ▼ |
| 2. Print " 1.C TO F | ALPHA 2ndF PRGM A 1 2ndF PRGM A 2 1. 2ndF A-LOCK C SPACE T O SPACE F ALPHA ▼ |
| 3. Print " 2.F TO C | 2ndF PRGM A 1 2ndF PRGM A 2 2. 2ndF A-LOCK F SPACE T O SPACE C ALPHA ▼ |
| 4. Input S | 2ndF PRGM A 3 2ndF A-LOCK S ALPHA ▼ |
| 5. If S = 1 Goto C TO F | 2ndF PRGM B 3 2ndF A-LOCK S = ALPHA 1 2ndF PRGM B 2 2ndF A-LOCK C T O F ALPHA 2ndF PRGM H 1 ▼ |
| 6. If S = 2 Goto F TO C | 2ndF PRGM H 2 ▶ ▶ ▶ 2 ▶ ALPHA F ▶ ▶ ALPHA C ▼ |
| 7. Goto START | 2ndF PRGM B 2 2ndF A-LOCK S T A R T ALPHA ▼ |
| 8. Label C TO F | 2ndF PRGM B 1 2ndF A-LOCK C T O F ALPHA ▼ |
| 9. Input C | 2ndF PRGM A 3 ALPHA C ▼ |
| 10. (9/5) × C + 32⇒F | ( 9 ÷ 5 ) × ALPHA C + 32 STO ALPHA F ▼ |
| 11. Print " F | 2ndF PRGM A 1 2ndF PRGM A 2 ALPHA F ▼ |
| 12. Print F | 2ndF PRGM A 1 ALPHA F ▼ |
| 13. End | 2ndF PRGM A 6 ▼ |
| 14. Label F TO C | 2ndF PRGM B 1 2ndF A-LOCK F T O C ALPHA ▼ |
| 15. Input F | 2ndF PRGM A 3 ALPHA F ▼ |
| 16. (5/9) × (F-32) ⇒C | ( 5 ÷ 9 ) × ( ALPHA F − 32 ) STO ALPHA C ▼ |
| 17. Print " C | 2ndF PRGM A 1 2ndF PRGM A 2 ALPHA C ▼ |
| 18. Print C | 2ndF PRGM A 1 ALPHA C ▼ |
| 19. End | 2ndF PRGM A 6 ▼ |

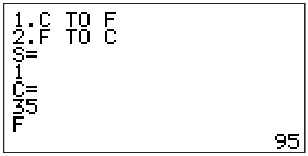
### Execution:

Execute the program. After pressing [2ndF] [QUIT] [2ndF] [PRGM] [A], select the program (CONVERT) and press [ENTER].

When the program starts executing, a request will be made for the method of calculation, followed by a request for input of the temperature. When the temperature has been input, the program will display the results.

**<Example>**

Conversion of 35°C to °F will appear as shown to the right.




## (2) Random substitution of numbers

- Create a program that fills the matrix M × N with random numbers from 0 to 9.
- The file name is “MATFILL”.

### Input:

The program command input method ([2ndF] [PRGM]) was explained in the previous example so only items requiring special caution will be explained here.

| Program | Key operation |
|---|---|
| MATFILL | |
| 1. Input N | |
| 2. Input M | |
| 3. {N, M} ⇒ dim(mat A) | [2ndF] [{] [ALPHA] [N] [,] [ALPHA] [M] [2ndF] [}] [STO] [MATRIX] [C] [0] [1] [MATRIX] [A] [1] [)] [▼] |
| 4. 1 ⇒ I | |
| 5. Label FILL I | |
| 6. 1 ⇒ J | |
| 7. Label FILL J | |
| 8. round (random, 3)⇒ matA (I, J) | [MATH] [B] [2] [MATH] [C] [1] [,] 3 [)] [STO] [MATRIX] [A] [1] [(] [ALPHA] [I] [,] [ALPHA] [J] [)] [▼] |
| 9. J + 1⇒J | * Processing and display of the rounding of random numbers to 3 decimal places. |
| 10. If J ≤ M Goto FILL J | |
| 11. I + 1 ⇒ I | |
| 12. If I ≤ N Goto FILL I | |
| 13. Print matA | |
| 14. End | |

**Execution:**

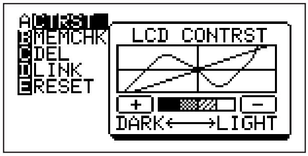
Execute the program. After pressing 2ndF QUIT 2ndF PRGM A, select the program (MATFILL) and then press ENTER.

When the program starts executing, the line will be defined and then the random numbers will be stored in Mat A. To view the contents of Mat A on the screen, select MATRIX A 1 and then press ENTER .

# CHAPTER 13
# OPTION FUNCTIONS

- The calculator is equipped with option functions for features such as adjusting display contrast, checking memory, deleting, link menu, etc.
- Press [2ndF] [OPTION] to open the option menu.

  A: Display contrast adjustment
  B: Memory usage check
  C: Delete files
  D: Link between another EL-9650 or Personal computer
  E: Reset the calculator



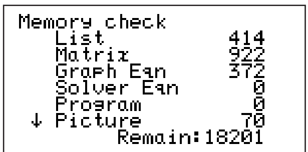

## 1. Adjusting Screen Contrast

- The contrast adjust screen as shown above will appear when pressing [2ndF] [OPTION].
- Press [−] while in this screen to lighten contrast. Press [+] to darken contrast. Adjust accordingly.
  (It is possible to change the contrast by touching [−] or [+] using the touch-pen, instead of using manual key entry.)

## 2. Checking Memory Usage

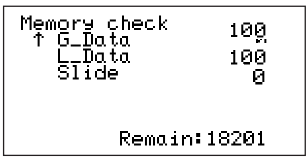
- The memory usage check screen, as shown on the right, will appear when pressing [2ndF] [OPTION] [B].
- This screen displays the remaining user space. (The sample screen indicates that there are 18201 bytes of empty space).
- The user memory is shared by graph equations, graph screens, matrices, etc.
- For a detailed check on the memory usage, press [ENTER] while in this screen. Memory usage for each mode is displayed accordingly, as shown on the right, with the remaining memory shown at the bottom.
- The "🠗" on the bottom left of the screen indicates that there is a following screen.
- To view the next screen, press [▼].


The first screen of memory check




[▼]

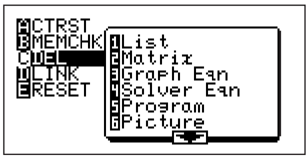
The second screen of memory check



- The displayed items are defined as follows:
  **List:** shows the memory used by lists
  **Matrix:** shows the memory used by matrices
  **Graph Eqn:** shows the memory used by graph equations
  **Solver Eqn:** shows the memory used by solver equations
  **Program:** shows the memory used by programs
  **Picture:** shows the memory used by graph pictures
  **G_Data:** shows the memory used by registered graph data
  **L_Data:** shows the memory used by registered list data
  **Slide:** shows the memory used by user-made slide shows
- Numbers are expressed in bytes.
  * The displayed items are only an example. This display differs according to use.
- Always check the free memory capacity in the calculation result display mode when you use the Equation Editor. If you check the free memory capacity in any other mode, the capacity may not be displayed accurately.
- The Equation Editor uses part of the user area. Therefore, the memory capacity that the Editor can temporarily use may vary depending on the free memory capacity. You cannot use the Equation Editor unless the free memory capacity is approximately least 500 bytes or more.

# 3. Deleting Files

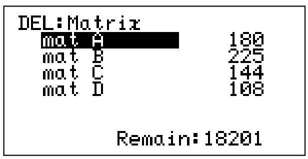
- The delete menu will appear when pressing [2ndF] [OPTION] [C].
- Deletions can be executed per data entry. Data separation is the same as for the previously mentioned memory check. However, lists, matrices, etc. are classified even further.



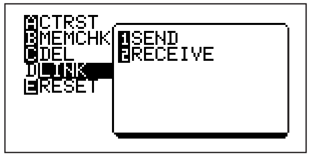

**<Example>**

Delete matrix “mat C”.

1. Press [2ndF] [OPTION] [C] [2].
   The cursor pointer will appear at the location of “mat A”.
2. Move the cursor pointer to “mat C” by pressing [▼] [▼].
3. Press [ENTER] to delete the matrix.
   * The displayed items are only an example. This display differs according to use.
   * Press [2ndF] [QUIT] to cancel the deleting operation.



# 4. Link Function

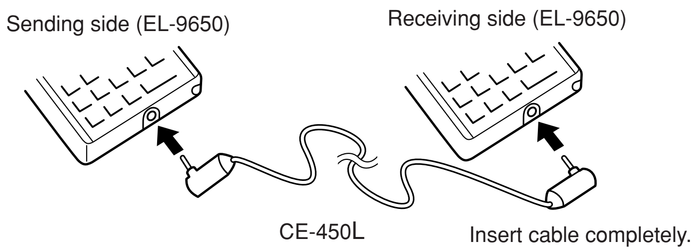



- The EL-9650 is capable of being linked to other EL-9650s and personal computers for data communication by using optional parts (CE-450L and CE-LK1).
- Use this menu for data transmission with other devices.
- The display screen shown to the right will appear when pressing [2ndF] [OPTION] [D].
  [1 SEND]- Sends data
  [2 RECEIVE]- Receives data

## (1) To link with another EL-9650 (Communication between EL-9650s)

- The specified file of the current mode is sent and received.
- Operations for the sender and the receiver are as follows.

### Connection method for communication between EL-9650s :

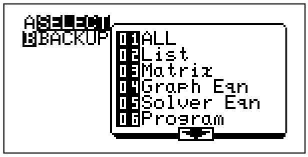



| Sender | Receiver |
|---|---|
| 1. Both the sender and receiver must press [2ndF] [OPTION] [D]. | |
| 2. | Press [2].<br>* A display for the receive mode will appear on-screen. |
| 3. Press [1]. | |
| 4. Specify data or file to be sent, following the procedure described later in the text. | |
| 5. Press [2ndF] [EXE] . | |
| 6. Initiate transmission (send)<br>* A busy display will appear on-screen during transmission. | Initiate transmission (receive). |

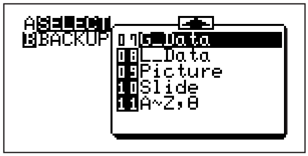
* Please be aware that if there are existing data on the receiving side, the existing data will be overwritten.
* Make sure that the communication cables are inserted properly so that they do not come unattached.
* The number of files that can be selected at one time for sending is 10.

## Selecting data to send:

- The data to be sent by the LINK menu (sender) can be specified individually.
- Press 2ndF OPTION D 1 to display SEND menu




▶ ALPHA ▼

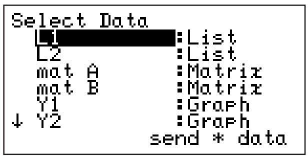



[A SELECT] ............. Sends files individually as described below.
[01 ALL] .............. Selects and displays all files.
[02 List] ............... Selects and displays all list files.
[03 Matrix] ........... Selects and displays all matrix files.
[04 Graph Eqn] ... Selects and displays all graph equations.
[05 Solver Eqn] ... Selects and displays all solver equations.
[06 Program] ....... Selects and displays all program files.
[07 G_Data] ........ Selects and displays all graph data files.
[08 L_Data] ......... Selects and displays all list data files.
[09 Picture] ......... Selects and displays all picture data files.
[10 Slide]............. Selects and displays all self-made slide shows.
[11 A ~ Z, θ] .......... Selects and displays all fixed memory of A to Z, and θ.

[B BACKUP] ............ Menu to send all data of files. Use this feature to send the entire content.

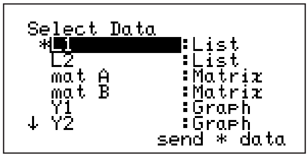
**<Example>**

The operation procedure to send list “L1” and matrices “mat A, mat B”, as well as graph equation “Y2”, is explained below.

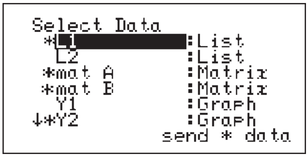



1. After selecting [1 SEND] in the LINK menu, press 0 1.

- All registered files are displayed as shown on the right (3 types of file are displayed on the right side of the screen).
- The cursor is positioned at the very top line.
- First select list “L1” for send.




2. Press (ENTER). A “*” mark will flash to the left of L1 (“*” indicates that the item has been selected for sending).
   - Select the remaining files using the same procedure.




3. Press (▼) (▼) (ENTER) (▼) (ENTER) (▼) (▼) (ENTER) to complete selection.
4. When the settings on the receiving side are complete, press (2ndF) (EXE) to start transmission.

* In the example above, [01 ALL] was selected since there were many types of data files (list, matrix, etc.). However, [02 List] or [03 Matrix] can be used when sending only list or matrices.

### (2) Data communication between the EL-9650 and a Personal computer

- CE-LK1 (separately sold) is required for data communications with Personal computers.
- The CE-LK1 includes a communication cable and software.
- Please see the CE-LK1 operation manual for connections.
- For communications with Personal computers, no operations are needed on the EL-9650 side for either receiving or sending, once the power supply is turned on. All operations are controlled on the Personal computer side.

## 5. Reset Function

- Press (2ndF) (OPTION) (E) to enter the reset mode.
- Use this function to return the settings to their default values or to delete all data.
- See CHAPTER 1 “14. Resetting the Calculator” for details on page 34.

## (1) When trouble occurs

If a problem occurs after replacing the batteries, or if the calculator does not function properly even after the above RESET operation, perform the following:

1. Press the RESET switch on the back.
2. Press ON.

- Returns to the initial display.

***CAUTION***

**Do not press CL in step 2. Pressing CL will delete all data stores in the calculator.**

# APPENDIX

## 1. Replacing the Batteries

**Batteries used in the calculator:**

| Type | Model | Q'ty | Use |
|---|---|---|---|
| Manganese battery | AAA (R03) | 4 | Unit operation |
| Lithium battery | CR2032 | 1 | Memory backup |

With normal use, the AAA batteries last about 150 hours, and the lithium backup battery lasts 5 years. The original batteries are included from the time of shipment and so might run down sooner than these operating times.

***CAUTION***

**To prevent loss of stored data, replace only one type of battery at a time.**

### (1) Battery precautions

- Keep the batteries out of the reach of children.
- When batteries become weak, remove them from the calculator immediately. If depleted batteries are left in the calculator for any length of time, they might leak and cause corrosion inside the calculator.
- Do not dispose of batteries in fire or water, as they may explode.

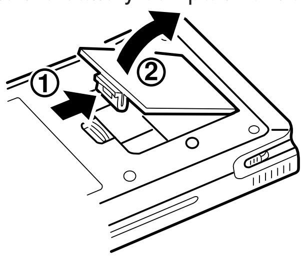
### (2) Replacing the operating batteries

When the battery replacement message shown to the right appears in the display, replace all four AAA batteries as follows.

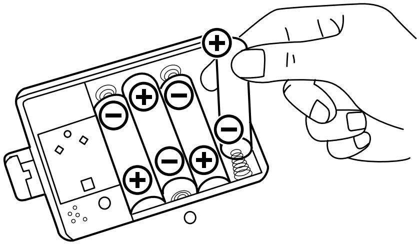
```
   <ATTENTION>
The OPERATING
batteries are depleted
. Read OPERATION
MANUAL for detail.
```

* If you continue using the calculator after the caution message has been displayed, the power may not turn on when ON is pressed.

1. Turn off the calculator by pressing 2ndF OFF, then take off the hard cover.
2. Turn over the calculator and locate the battery compartment cover.
3. Open the cover as illustrated.



4. Replace all four batteries. Be sure to insert the batteries as shown in the illustration.



5. Replace the battery compartment cover. The following message appears.

```
PRESS [CL] KEY TO
CLEAR ALL DATA

PRESS [ON] KEY TO
CANCEL
```

If you do not see the message, repeat steps 2 to 5.

6. Press [ON].

***CAUTION***

**Do not press [CL]. This will clear all the data.**

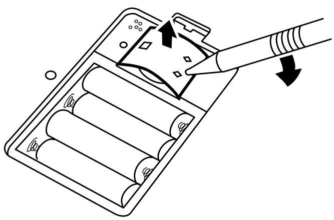
7. If the display becomes hard to see, adjust the display contrast.
   (Press [2ndF] [OPTION] and [−] (lighter) or [+] (darker) until the contrast is set correctly.)

## (3) Replacing the memory backup battery

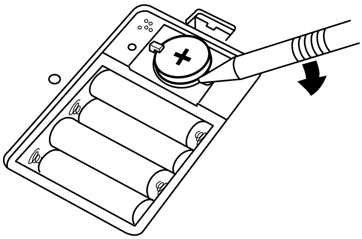
Replace the backup battery every 5 years as follows:

* If you do not change the backup battery every 5 years, you risk losing all of the stored memory.

1. Open the battery compartment cover following steps 1, 2, and 3 of the operating battery replacement procedure.
2. Take off the memory backup cover label.



3. Using a pen or screwdriver as a lever, lift the battery out of its compartment.



4. Replace the battery with an identical 3V lithium battery (CR2032 or equivalent). Make sure the plus (+) sign faces up.
5. Replace the memory backup cover label.
6. Replace the battery compartment cover. The following message appears.
7. Press ON.

```
PRESS [CL] KEY TO
CLEAR ALL DATA

PRESS [ON] KEY TO
CANCEL
```

***CAUTION***

**Do not press CL. This will clear all the data.**

# 2. Specifications

| | |
|---|---|
| Model | EL-9650 |
| Product name | Graphing calculator |
| Display | 22 digits $\times$ 10 lines (dot matrix character format: when 5 $\times$ 7 dots)<br>Number of digits: mantissa 10 digits, exponents 2 digits (standard screen) 7 digit display (including negatives, decimals) for table screen, split screen, etc.<br>However, 10 digits for mantissa in the complex number mode<br>Display method: Numerical value display method specification, calculation equation input method (direct algebraic logic input / one-line input method), fraction display method specification, complex number display method specification. |
| Touch panel | Matrix type: 22 $\times$ 8 (character display area) |
| Calculation method | D.A.L. (Direct Algebraic Logic) |

| | |
|---|---|
| Model | EL-9650 |
| Calculation function | Manual calculation (arithmetic, parentheses calculation, memory calculation, function calculation, integral calculation, coordinate conversion), binary, octal, decimal and hexadecimal calculation, boolean operation, matrix calculation, complex number calculation, complex function calculation, statistic calculation, regression calculation, statistic authorization calculation, financial calculation, etc. |
| Input method | Manual key entry, pen-touch entry |
| Graphic function | Built-in slide show, shift/change, split-screen, Rapid Graph/ZOOM/ WINDOW<br>Rectangular coordinate graph, polar graph, parameter graph, sequence graph<br>Graph range specification, graph window mode automatic specification, graph plotting, trace, calculation function, zoom, picture input, paint, graph database register, etc. |
| Statistic function | 1-variable/2-variable statistical data input/calculation, register, edit and frequency input, regression calculation function, estimated statistic/authorization function, etc. |
| Solver function | Equation solver: numerical syntax analysis, Newton's law, graph analysis, solver equation register, etc. |
| List function | direct data entry/edit to list, calculation function for various lists, list/matrix conversion, etc. |
| Substitution function | Insert graph, numerical input from split-screen |
| Program function | Condition statement command, subroutine, graph, various function commands |
| Option function | Screen contrast adjustment, memory usage check, various data delete, data link (between EL-9650 and personal computer or other EL-9650) |
| Memory size | 32KB (user area: Equation edit mode… approx. 18.6KB, One-line edit mode… approx. 20.6KB) |
| Power supply | For operation: 6V ⎓ (DC) AAA battery (R03) × 4<br>Memory: 3V ⎓ (DC) Lithium battery (CR2032) × 1 |
| Automatic power off function | Approx. 10 minutes |

| | |
|---|---|
| Model | EL-9650 |
| Used temperature range | 0°C to 40°C (32°F to 104°F) |
| Power consumption | 0.13W |
| Battery life | Battery for operation: approx. 150 hours (with 5 minutes of continual use and 55 minutes in the display state for every hour with temperature approx. 20°C / 68°F)<br>Battery for memory: Approx. 5 years (under temperature of approx. 20°C / 68°F. When the batteries for operation are replaced frequently, as it is used)<br>(Note) These differ according to battery type, usage, ambient temperature, etc. |
| External dimensions | 86 mm (W) × 183 mm (D) × 19.5 mm (H)<br>3-3/8” (W) × 7-7/32” (D) × 25/32” (H) (without the protective cover) |
| Weight | 230 g (0.507 lb) (with batteries, without the protective cover) |
| Attached items | 4 AAA batteries (included), 1 lithium battery (installed), Operation manual, touch-pen |

# 3. Error Codes and Error Messages

| Error code | Error message | Error content |
|---|---|---|
| 01 | Syntax | Syntax error in equation or program |
| 02 | Calculate | Execution of a division using 0, calculation beyond calculation range, etc. |
| 03 | Nesting | Reservation of 14 or more numerical values or 32 or more functions during execution. |
| 04 | Invalid | Matrix definition error |
| 05 | Dimension | Inconsistency in the dimension of matrix during arithmetic of a matrix or dimension of list for STAT calculation. |
| 07 | Invalid DIM | Size of list and matrix input for calculation exceeds calculation range. |
| 08 | Argument | Inconsistency in argument of the structured function |
| 09 | Data Type | Invalid data type used in calculation |
| 10 | No Sign Change | Finance calculation error |
| 11 | No define | Undefined list or matrix |
| 12 | Domain | Argument definition outside of domain |
| 13 | Increment | Increment error |
| 16 | Irr Calc | More than two inflection points for Irr calculation |
| 17 | Stat Med | Med-Med law (statistic) error |
| 20 | No Argument | No argument entered |
| 21 | Not pair ∫ dx | Equation definition (∫ and dx as a pair) for integral calculus does not follow syntax. |
| 22 | Not pair [ ] | Not paired with specified “[]” |
| 23 | Not pair ( ) | Not paired with specified “()” |
| 24 | Not pair { } | Not paired with specified “{}” |
| 25 | Line over | Over line capacity |
| 26 | Not delete | Selection or execution of item unable to delete |
| 27 | Buffer over | Input or equation exceeds buffer capability |

| Error code | Error message | Error content |
|---|---|---|
| 30 | Editor type | Invalid editor type |
| 31 | Continue = | “=” exists in equation that has been recalled (RCL) |
| 32 | No data | Data does not exist |
| 33 | Graph Type | Error in graph type setting |
| 34 | Too many var. | Use of too many variables in the SOLVER mode |
| 35 | No variable | No variable in the specified equation of the SOLVER mode |
| 36 | No solution | No solution |
| 37 | No title | No title entered |
| 38 | Too many obj | More than 30 objects selected |
| 40 | Lbl duplicate | Same label name is used more than once within a program |
| 41 | Lbl undefined | Label is not defined for Goto or Gosub |
| 42 | Lbl over | More than 50 labels are used within a program |
| 43 | Gosub stack | Nesting of more than 10 subroutine stacks |
| 44 | Line too long | One line of program exceeds more than 160 characters |
| 45 | Can’t return | Use of return command without jumping from subroutine |
| 46 | Strage full | Attempt to create a file exceeding 99 (delete unnecessary files) |
| 47 | Coord type | Invalid coordinate system for command |
| 70 | I/O device | Communication error |
| 71 | Wrong Mode | Wrong communication set mode |
| 90 | Memory over | Over memory capacity |
| 99 | System error | User memory space cannot be secured |
| | Low battery | Interruption due to low battery |
| | BREAK!! | Interruption due to “ON” key |

# 4. Calculation Equation Error Conditions Used by This Unit

## (1) Financial

* Define constants “r” and “s” when using in the equation below.

$$r=\left(\frac{I(\%)}{100}\div C/Y+1\right)^{\frac{C/Y}{P/Y}}-1\ ,\quad \left\{\begin{matrix} S=1\ (Pmt\_Begin) \\ S=0\ (Pmt\_End)\end{matrix}\right\}$$

### 1. I% calculation

① If PMT=0

$$r=\left(-\frac{PV}{FV}\right)^{-\frac{1}{n}}-1$$

② If PMT≠0

$$f(r)=PV+(1+r\times s)\times PMT\times\frac{1-(1+r)^{-n}}{r}+FV\times(1+r)^{-n}:\ (r\neq 0)$$

$$f(r)=PV+PMT\times n+FV:\ (r=0)$$

Calculate the following for r solved in ① and ②

$$I(\%)=100\times C/Y\times\left((r+1)^{\frac{P/Y}{C/Y}}-1\right)$$

### 2. PV calculation

① If $r\neq 0$, $r>-1$

$$PV=-(1+r\times s)\times\frac{1-(1+r)^{-n}}{r}\times PMT-FV\times(1+r)^{-n}$$

② If r=0

$$PV=-n\times PMT-FV$$

③ If $r\leq -1$

Error

### 3. FV calculation

① If $r \neq 0$, $r > -1$

$$FV = -\frac{PV + (1 + r \times s) \times \dfrac{1-(1+r)^{-n}}{r} \times PMT}{(1+r)^{-n}}$$

② If $r = 0$

$$FV = -n \times PMT - PV$$

③ If $r \leq -1$

Error

### 4. PMT calculation

① If $r \neq 0$, $r > -1$

$$PMT = -\frac{PV + FV \times (1+r)^{-n}}{(1 + r \times s) \times \dfrac{1-(1+r)^{-n}}{r}}$$

② If $r = 0$

$$PMT = -\frac{PV + FV}{n}$$

③ If $r \leq -1$

Error

### 5. N calculation

① If $r \neq 0$, $r > -1$

$$N = -\frac{\log\left\{\dfrac{PV + \dfrac{1}{r} \times (1 + r \times s) \times PMT}{\dfrac{1}{r} \times (1 + r \times s) \times PMT - FV}\right\}}{\log(1+r)}$$

② If $r = 0$

$$N = -\frac{FV + PV}{PMT}$$

③ If $r \leq -1$

Error

## (2) Error conditions during financial calculations

- $r \leq -1$
- N = 0 in PMT calculations
- I% = 0 and PMT = 0, or I% ≠ 0 and FV = (1/r) (1 + r × s) × PMT, in N calculations.
  s = 1 (Pmt_Begin)
  s = 0 (Pmt_End)

In I% calculations

If PMT > 0:

| | |
|---|---|
| Pmt_End mode: | PV ≥ 0 and FV + PMT ≥ 0 |
| | PV < 0 and FV + PMT < 0 |
| Pmt_Begin mode: | PV + PMT ≥ 0 and FV ≥ 0 |
| | PV + PMT < 0 and FV < 0 |

If PMT < 0:

| | |
|---|---|
| Pmt_End mode: | PV > 0 and FV + PMT > 0 |
| | PV ≤ 0 and FV + PMT ≤ 0 |
| Pmt_Begin mode: | PV + PMT > 0 and FV > 0 |
| | PV + PMT ≤ 0 and FV ≤ 0 |

If PMT = 0: PV ÷ FV ≥ 0

- FV, N × PMT, PV ≥ 0 or FV, N × PMT, PV ≤ 0
- Irr calculation: All cash flows have the same sign.

## (3) Distribution function

① pdfnorm(

$$f(x) = \frac{1}{\sqrt{2\pi}\,\sigma} \exp\left(-\frac{(x-\mu)^2}{2\sigma^2}\right)$$

Calculation result→Xreg

μ: Mean
σ: Standard deviation

② pdfT(

$$f(x) = \frac{\Gamma\left(\frac{df+1}{2}\right)}{\Gamma\left(\frac{df}{2}\right)} \frac{\left(1+\frac{x^2}{df}\right)^{-\frac{df+1}{2}}}{\sqrt{\pi df}}$$

However: $\Gamma(s) = \int_0^{\infty} x^{s-1} e^{-x}\, dx$

Calculation result→Xreg

③ pdfχ² (

$$f(\chi^2, df) = \frac{1}{2\Gamma(\frac{df}{2})}(\frac{\chi^2}{2})^{\frac{df}{2}-1} e^{(-\frac{\chi^2}{2})}$$

However: $\Gamma(s) = \int_0^\infty x^{s-1} e^{-x} dx$

df: Degree of freedom

④ pdfF(

$$f(x) = \frac{\Gamma(\frac{m+n}{2})}{\Gamma(\frac{m}{2})\ \Gamma(\frac{n}{2})}(\frac{m}{n})^{\frac{m}{2}} x^{\frac{m}{2}-1}(1+\frac{mx}{n})^{-\frac{m+n}{2}}$$

However: $\Gamma(s) = \int_0^\infty x^{s-1} e^{-x} dx$

m: Degree of freedom of numerator
n: Degree of freedom of denominator

⑤ pdfbin(

$$P(x=0) = (1-p)^n$$

$$P(x=c+1) = \frac{(n-c)\,p}{(c+1)(1-p)} P(x=c)$$

(c=0,1,…, n–1)

n: Trial number (integers greater than 0)
p: Success probability ($0 \le p \le 1$)
c: Success number

⑥ pdfpoi(

$$f(x) = \frac{e^{-\mu}\mu^x}{x!}$$

(x=0, 1, 2, ...)

⑦ pdfgeo(

$$f(x) = p(1-p)^{x-1}$$

x: First successful trial number

# 5. Calculation Range

## Arithmetic Calculation

The results for dividend, multiplicand and operand are:

$-1 \times 10^{100} < x \leq -1 \times 10^{-99}$, $1 \times 10^{-99} < x \leq 1 \times 10^{100}$ or 0

(valid within the range of display capability)

Please note that results and input numerical values less than $1 \times 10^{-99}$ are considered to be 0.

## Function calculation

| Function | Calculation range | Notes |
|---|---|---|
| sin x<br>cos x<br>tan x | DEG : $\lvert x\rvert < 1 \times 10^{10}$<br>RAD : $\lvert x\rvert < \frac{\pi}{180} \times 10^{10}$<br>GRAD : $\lvert x\rvert < \frac{10}{9} \times 10^{10}$<br>However, the following are excluded for tan x<br>DEG : $\lvert x\rvert = 90\ (2n-1)$<br>RAD : $\lvert x\rvert = \frac{\pi}{2}\ (2n-1)$<br>GRAD : $\lvert x\rvert = 100\ (2n-1)$ | "n" is an integer |
| $\sin^{-1} x$<br>$\cos^{-1} x$ | $-1 \leq x \leq 1$ | |
| $\tan^{-1} x$ | $\lvert x\rvert < 1 \times 10^{100}$ | |
| sinh x<br>cosh x<br>tanh x | $-230.2585093 \leq x \leq 230.2585092$ | |
| $\sinh^{-1} x$ | $\lvert x\rvert < 1 \times 10^{50}$ | |
| $\cosh^{-1} x$ | $1 \leq x \leq 1 \times 10^{50}$ | |
| $\tanh^{-1} x$ | $\lvert x\rvert < 1$ | |
| ln x<br>log x | $1 \times 10^{-99} \leq x < 1 \times 10^{100}$ | $\ln x = \log_e x$ |
| $e^x$ | $-1 \times 10^{100} < x \leq 230.2585092$ | $e \fallingdotseq 2.71828 \ldots$ |
| $10^x$ | $-1 \times 10^{100} < x < 100$ | |

| Function | Calculation range | Notes |
|---|---|---|
| $X^{-1}$ | $\lvert x \rvert < 1 \times 10^{100}$ | $X \neq 0$ |
| $X^2$ | $\lvert x \rvert < 1 \times 10^{50}$ | |
| $\sqrt{x}$ | $0 \leq x < 1 \times 10^{100}$ | |
| n! | $-0.5 \leq n \leq 69.5$ | n is an integer or integer + 0.5 |
| $a^b$ (^) | When $a > 0$,<br>$-1 \times 10^{100} < b \log a < 100$<br>When $a = 0$,<br>$0 < b < 1 \times 10^{100}$<br>When $a < 0$,<br>b is an integer or $\frac{1}{b}$ is an odd number ($b \neq 0$)<br>However, $-1 \times 10^{100} < b \log \lvert a \rvert < 100$ | $a^b = 10^{b \cdot \log a}$ |
| $\sqrt[a]{b}$ | When $b > 0$,<br>$-1 \times 10^{100} < \frac{1}{a} \log b < 100$, $a \neq 0$<br>When $b = 0$,<br>$0 < a < 1 \times 10^{100}$<br>When $b < 0$,<br>a is an odd number or $\frac{1}{a}$ is an integer, ($a \neq 0$)<br>However, $-1 \times 10^{100} < \frac{1}{a} \log \lvert b \rvert < 100$ | $\sqrt[a]{b} = 10^{\frac{1}{a} \log b}$ |
| nPr<br>nCr | $0 \leq r \leq n \leq 69$ | n and r are positive integers |

| Function | Calculation range | Notes |
|---|---|---|
| dec<br>bin<br>oct<br>hex | Decimal: $\lvert x\rvert \leq 9999999999$<br>Binary: $1000000000000000 \leq x$<br>$\leq 1111111111111111$<br>$0 \leq x \leq 0111111111111111$<br>Octal: $4000000000 \leq x \leq 7777777777$<br>$0 \leq x \leq 3777777777$<br>Hexadecimal: FDABF41C01 ≤ x ≤ FFFFFFFFFF<br>0 ≤ x ≤ 2540BE3FF | x is an integer |
| →dms<br>→deg | $\lvert X\rvert < 1 \times 10^{100}$ | |
| xy → r<br>xy → θ | $\lvert x\rvert < 1 \times 10^{100}$, $\lvert y\rvert < 1 \times 10^{100}$<br>$\sqrt{x^2+y^2} < 1 \times 10^{100}$<br>$\lvert \frac{y}{x} \rvert < 1 \times 10^{100}$ | $r = \sqrt{x^2+y^2}$<br>$\theta = \tan^{-1} \frac{y}{x}$ |
| rθ → x<br>rθ → y | $\lvert r\rvert < 1 \times 10^{100}$ | $x = r \cos\theta$,<br>$y = r \sin\theta$<br>The range of θ is the same as x of sin x and cos x |
| not | Binary: $1000000000000000 \leq x$<br>$\leq 1111111111111111$<br>$0 \leq x \leq 0111111111111111$<br>Octal: $4000000000 \leq x \leq 7777777777$<br>$0 \leq x \leq 3777777777$<br>Hexadecimal: FDABF41C01 ≤ x ≤ FFFFFFFFFF<br>0 ≤ x ≤ 2540BE3FE | Other Boolean operations are the same as not and neg |
| neg | Binary: $1000000000000001 \leq x$<br>$\leq 1111111111111111$<br>$0 \leq x \leq 0111111111111111$<br>Octal: $4000000001 \leq x \leq 7777777777$<br>$0 \leq x \leq 3777777777$<br>Hexadecimal: FDABF41C01 ≤ x ≤ FFFFFFFFFF<br>0 ≤ x ≤ 2540BE3FF | |

| Function | Calculation range | Notes |
|---|---|---|
| Statistic calculations | $\lvert x \rvert < 1 \times 10^{50}$<br>$\lvert y \rvert < 1 \times 10^{50}$<br>$\lvert \Sigma x \rvert < 1 \times 10^{100}$<br>$\Sigma x^2 < 1 \times 10^{100}$<br>$\lvert \Sigma y \rvert < 1 \times 10^{100}$<br>$\Sigma y^2 < 1 \times 10^{100}$<br>$\lvert \Sigma xy \rvert < 1 \times 10^{100}$<br>$\lvert n \rvert < 1 \times 10^{100}$ | |
| $\overline{x}$ | $n \neq 0$ | Same for $\overline{y}$, sy and σy |
| sx | $n > 1$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$0 \leq \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1} < 1 \times 10^{100}$ | |
| σx | $n > 0$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$0 \leq \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n} < 1 \times 10^{100}$ | |
| r | $n > 0$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$\lvert \Sigma y \rvert < 1 \times 10^{50}$<br>$0 < (\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n}) < 1 \times 10^{100}$<br>$\lvert \Sigma xy - \frac{\Sigma x \Sigma y}{n} \rvert < 1 \times 10^{100}$<br>$\left\lvert \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\sqrt{(\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n})}} \right\rvert < 1 \times 10^{100}$ | |

| Function | Calculation range | Notes |
| --- | --- | --- |
| b | $n > 0$<br>$\lvert\Sigma x\rvert < 1 \times 10^{50}$<br>$\lvert(\Sigma x)(\Sigma y)\rvert < 1 \times 10^{100}$<br>$0 < \left\lvert\Sigma x^2 - \frac{(\Sigma x)^2}{n}\right\rvert < 1 \times 10^{100}$<br>$\left\lvert\Sigma xy - \frac{\Sigma x \Sigma y}{n}\right\rvert < 1 \times 10^{100}$<br>$\left\lvert\frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}\right\rvert < 1 \times 10^{100}$ | Regression calculations excluding 2nd, 3rd and 4th degree polynomials. |
| a | $\lvert b\bar{x}\rvert < 1 \times 10^{100}$<br>$\lvert\bar{y} - b\bar{x}\rvert < 1 \times 10^{100}$ | Same as above.<br>Same as b for other. |
| y' | $\lvert bx\rvert < 1 \times 10^{100}$<br>$\lvert a + bx\rvert < 1 \times 10^{100}$ | |
| x' | $\lvert y - a\rvert < 1 \times 10^{100}$<br>$\left\lvert\frac{y-a}{b}\right\rvert < 1 \times 10^{100}$ | |

In principle, the residual for calculations is ±1 of the last digit (in case of exponential display, the residual is ±1 of the last digit of the mantissa display).
However, the residual increases in continuous calculations due to accumulation of each residual (this is the same for squares ($a^b$) and square roots ($\sqrt[a]{b}$) where continuous calculations are performed internally).
Moreover, errors will accumulate and become larger in the vicinity of inflection points and singular points of functions.

## Complex number calculations

| Function | Calculation range | Notes |
|---|---|---|
| $\dfrac{1}{x + yi}$ | $\|x\| < 10^{50}$<br>$\|y\| < 10^{50}$ | $x + yi \neq 0$ |
| $(x + yi)^2$ | $\|x\| < 10^{50}$<br>$\|y\| < 10^{50}$<br>$\|xy\| < 5 \times 10^{99}$ | |
| $\ln(x + yi)$<br>$\log(x + yi)$<br>$\sqrt{x+yi}$ | $\|x\| < 10^{50}$<br>$\|y\| < 10^{50}$<br>$\left\|\frac{y}{x}\right\| < 10^{100}$ | |
| $e^{(x + yi)}$ | $\|x\| < 230$<br>$\|y\| < 230$ | |
| $10^{(x + yi)}$ | $\|x\| < 100$<br>$\|y\| < 100$ | |
| $(x + yi)^{(a + bi)}$ | $\|x\| < 10^{50}$<br>$\|y\| < 10^{50}$<br>$\|a\| < 10^{100}$<br>$\|b\| < 10^{100}$ | |
| List | Error is returned when the number of elements exceeds 1,000. | This is the same when the result of a list function specifies 1,000 or more elements. |
| Matrix | Error is returned when specifying columns or rows that exceed 100. | |

# 6. Explanation of EL-9650 menus

Note: Numerical values, equations, variables, lists, etc. are entered in A and B. [ ] indicates that it may be omitted. (CPLX) indicates that the function can be used in the complex number mode. Major categories marked with an asterisk (*) are used only for explanation and are not related to actual keys or display indications.

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | SET UP | A --------- | | | Current SET UP setting condition display screen | |
| | | B DRG | 1 | Deg | Sets angles to the Deg mode | A mode is fixed by selecting in the menu screen |
| | | | 2 | Rad | Sets angles to the Rad mode | " |
| | | | 3 | Grad | Sets angles to the Grad mode | " |
| | | C FSE | 1 | FloatPt | Sets to the floating point display mode | " |
| | | | 2 | Fix | Sets to the fixed point display mode | " |
| | | | 3 | Sci | Sets to the scientific notation display mode | " |
| | | | 4 | Eng | Sets to the engineering notation display mode (exponents are in multiples of three) | " |
| | | D TAB | 1 to 9, and 0 | 1 to 9, and 0 | Sets number of decimal point places (range from 0 - 9) | " |
| | | E COORD | 1 | Rect | Sets to rectangular coordinate mode | " |
| | | | 2 | Param | Sets to parametric variable coordinate mode | " |
| | | | 3 | Polar | Sets to polar coordinate mode | " |
| | | | 4 | Seq | Sets to sequence coordinate mode | " |
| | | F ANSWER | 1 | Decimal (Real) | Sets answer display to the decimal mode | " |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | SET UP | F ANSWER | 2 | Mixed (Real) | Sets answer display to the mixed fraction mode | A mode is fixed by selecting it in the menu screen |
| | | | 3 | Improp (Real) | Sets answer display to the improper fraction mode | ” |
| | | | 4 | x+yi (complex) | Sets answer display to the rectangular complex number mode | ” |
| | | | 5 | $r\angle\theta$ (complex) | Sets answer display to the polar complex number mode | ” |
| | | G EDITOR | 1 | Equation | Sets editor on mode to input equations as they appear | ” |
| | | | 2 | One line | Sets editor on mode to input one line at a time | ” |
| | FORMAT | A --------- | | | Current FORMAT setting condition display screen | |
| | | B CURSOR | 1 | RectCoord | Sets to rectangular coordinate graphing format | A mode is fixed by selecting it in the menu screen |
| | | | 2 | PolarCoord | Sets to polar coordinate graphing format | ” |
| | | C EXPRES | 1 | ON | Displays specified numerical equation on-graph screen | ” |
| | | | 2 | OFF | Deletes specified numerical equation on-graph screen | ” |
| | | D Y’ | 1 | ON | Displays graph slope (dy/dx) on-screen (valid only for X-Y coordinates) | ” |
| | | | 2 | OFF | Deletes graph slope (dy/dx) on-screen (valid only for X-Y coordinates) | ” |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| | FORMAT | E STYLE1 | 1 | Connect | Sets to connect plot mode. Reset all Y=graph line type to "–" | A mode is fixed by selecting it in the menu screen |
| | | | 2 | Dot | Sets to dot plot mode. Reset all Y=graph line type to "···" | " |
| | | F STYLE2 | 1 | Sequen | Sets to sequential graphing mode (draw one graph at a time) | " |
| | | | 2 | Simul | Sets to simultaneous graphing mode (draw multiple graphs at one time) | " |
| | | G TYPE | 1 | Web | Sets COB_web graph mode | " |
| | | | 2 | Time | Sets axis for progression graphing (set n to X axis and u(*n*), v(*n*) and w(*n*) to Y axis) | " |
| | [G TYPE] appears when coordinate system is set to seq in the SETUP menu | | 3 | uv | Sets axis for progression graphing (set u(*n*) to X axis and v(*n*) to Y axis) | " |
| | | | 4 | uw | Sets axis for progression graphing (set u(*n*) to X axis and w(*n*) to Y axis) | " |
| | | | 5 | vw | Sets axis for progression graphing (set v(*n*) to X axis and w(*n*) to Y axis) | " |
| | MATH | A CALC | 01 | $\log_2$ | Executes calculation using common logarithm of base (2) | $\log_2$ A |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATH | A CALC | 02 | $2^x$ | Executes calculation using squares | $2^A$ |
| | | | 03 | fmin ( | Calculates the variable when a function equation takes the smallest value | fmin (equation, lower limit, upper limit) List cannot be used for all arguments |
| | | | 04 | fmax ( | Calculates the variable when a function equation takes the largest value | fmax (equation, lower limit, upper limit) List cannot be used for all arguments |
| | | | 05 | d/dx ( | Calculates using differential calculus | d/dx (f(x), derivative [,∆x]) List cannot be used for all arguments |
| | | | 06 | ∫ | Calculates using integral calculus*1 (Gauss-kronrod method) | ∫ f(x), lower limit, upper limit [, tolerance*2] dx List cannot be used for all arguments |

*1 If f(x) has a discontinuity, then the calculator might lengthen the operation time and report an error.

*2 If not specified, the default setting is 1E-5.

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATH | A CALC | 07 | dx | Calculates using integral calculus (close equation beginning with ∫ with dx) | dx see above |
| | | | 08 | Σ ( | Calculates cumulative sum of a sequence equation | Σ (equation, initial value, end value [,increment]) |
| | | | 09 | sec | Calculates trigonometric function secant | sec A |
| | | | 10 | csc | Calculates trigonometric function cosecant | csc A |
| | | | 11 | cot | Calculates trigonometric function cotangent | cot A |
| | | | 12 | $sec^{-1}$ | Calculate inverse trigonometric function secant | $sec^{-1}$ A |
| | | | 13 | $csc^{-1}$ | Calculates inverse trigonometric function cosecant | $csc^{-1}$ A |
| | | | 14 | $cot^{-1}$ | Calculates inverse trigonometric function cotangent | $cot^{-1}$ A |
| | | | 15 | sinh | Calculates hyperbolic sine | sinh A |
| | | | 16 | cosh | Calculates hyperbolic cosine | cosh A |
| | | | 17 | tanh | Calculates hyperbolic tangent | tanh A |
| | | | 18 | $sinh^{-1}$ | Calculates archyperbolic sine | $sinh^{-1}$ A |
| | | | 19 | $cosh^{-1}$ | Calculates archyperbolic cosine | $cosh^{-1}$ A |
| | | | 20 | $tanh^{-1}$ | Calculates archyperbolic tangent | $tanh^{-1}$ A |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATH | B NUM | 1 | abs ( | Finds absolute value of real number, equation, list or matrix (CPLX) | abs (A) |
| | | | 2 | round ( | Round off at specified decimal place | round (a [,digit number of decimals]) |
| | | | 3 | ipart | Finds integer part of numerical value (CPLX) | ipart A |
| | | | 4 | fpart | Finds fractional part of numerical value (CPLX) | fpart A |
| | | | 5 | int | Change numerical value to integer value (CPLX) | int A |
| | | | 6 | min ( | Finds smallest value in valueA and valueB or return smallest value within a list | min(A,B) or min(list) |
| | | | 7 | max ( | Finds largest value in valueA and valueB or return largest value within a list | max(A,B) or max(list) |
| | | | 8 | lcm ( | Finds least common multiple of valueG and valueH that are real numbers or lists | lcm (G,H)<br>G and H are synchronized by list or numerical value |
| | | | 9 | gcd ( | Finds greatest common divisor of valueG and valueH that are real numbers or lists | gcd (G,H)<br>G and H are synchronized by list or numerical value |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATH | C PROB | 1 | random | Executes random numbers | random[(number of random numbers)] Listing of random numbers is not possible |
| | | | 2 | nPr | Finds the number of items in sequence (between list A and B, list and each element, numerical value, list and numerical value, etc.) | A $_nP_r$ B |
| | | | 3 | nCr | Finds the number of com-bined items (between list A and B, list and each element, numerical value, list and numerical value, etc.) | A $_nC_r$ B |
| | | | 4 | ! | Calculates factorials | A! |
| | | D CONV | 1 | →deg | Converts sexagesimals to decimals | A→deg |
| | | | 2 | →dms | Converts decimals to sexagesimals | A→dms |
| | | | 3 | xy→r ( | Finds r from specified rectangular coordinates | xy→r(A, B) |
| | | | 4 | xy→θ ( | Finds θ from specified rectangular coordinates | xy→θ(A, B) |
| | | | 5 | rθ→x ( | Finds X from specified polar coordinates | rθ→x(A, B) |
| | | | 6 | rθ→y ( | Finds Y from specified polar coordinates | rθ→y(A, B) |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| | MATH | E ANGLE | 1 | ° | Degree input and DRG conversion (for example entered (A° B' C")° in the RAD mode is converted to DEG) | Numerical value ° [numerical value ' numerical value "] A° |
| | | | 2 | ' | Minute input | Numerical value ° numerical value ' [numerical value "] |
| | | | 3 | " | Second input Used to enclose characters for print in programs (Print command) | Numerical value ° numerical value ' numerical value " Print "character string["] |
| | | | 4 | r | Rad conversion | $A^r$ |
| | | | 5 | g | Grad conversion | $A^g$ |
| | | F INEQ | 1 | = | Test operation that compares values on the right with the left. Returns 1 if true and 0 if false | A = B |
| | | | 2 | ≠ | Test operation that compares values on the right with the left. Returns 1 if true and 0 if false | A ≠ B |
| | | | 3 | > | Test operation that compares values on the right with the left. Returns 1 if true and 0 if false | A > B |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| | MATH | F INEQ | 4 | ≥ | Test operation that compares values on the right with the left. Returns 1 if true and 0 if false | A ≥ B |
| | | | 5 | < | Test operation that compares values on the right with the left. Returns 1 if true and 0 if false | A < B |
| | | | 6 | ≤ | Test operation that compares values on the right with the left. Returns 1 if true and 0 if false | A ≤ B |
| | | G LOGIC | 1 | and | Boolean operator used for N-base calculations (and) | A and B |
| | | | 2 | or | Boolean operator used for N-base calculations (or) | A or B |
| | | | 3 | not | Boolean operator used for N-base calculations (not) | not A |
| | | | 4 | xor | Boolean operator used for N-base calculations (xor) | A xor B |
| | | | 5 | xnor | Boolean operator used for N-base calculations (xnor) | A xnor B |
| | | H COMPLX | 1 | conj ( | Finds conjugate complex number of a complex number, or conjugate complex number of a complex number list (CPLX) | conj (A) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATH | H COMPLX | 2 | real ( | Finds real number of a complex number, or conjugate complex number of a complex number list (CPLX) | real (A) |
| | | | 3 | image ( | Finds imaginary number of complex number, or complex number list (CPLX) | image (A) |
| | | | 4 | abs ( | Finds absolute number of real number, equation, list or matrix (CPLX) | abs (A) |
| | | | 5 | arg ( | Finds argument of complex number (CPLX) | arg (A) |
| | N-MATH | A LOGIC | 1 | and | Boolean operator for use in N-base calculations (and) | A and B |
| | [A LOGIC] appears when pressing MATH while N-base calculation mode is selected | | 2 | or | Boolean operator for use in N-base calculations (or) | A or B |
| | | | 3 | not | Boolean operator for use in N-base calculations (not) | not A |
| | | | 4 | neg | Boolean operator for use in N-base calculations (neg) | neg A |
| | | | 5 | xor | Boolean operator for use in N-base calculations (xor) | A xor B |
| | | | 6 | xnor | Boolean operator for use in N-base calculations (xnor) | A xnor B |
| | LIST | A OPE | 1 | sortA ( | Sorts elements of list names in ascending order (sorts list elements in the order from the lowest value to the highest value) | sortA(list name)<br>sortA(list name, subordinate list name 1... subordinate list name n) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | LIST | A OPE | 2 | sortD ( | Sorts elements of list names in descending order (sorts list elements in the order from the highest value to the lowest value) | sortD(list name) sortD(list name, subordinate list name 1... subordinate list name n) |
| | | | 3 | dim ( | Finds list length and matrix size<br>Defines list length and matrix size | dim (list name) dim (matrix name) (matrix size is returned with list)<br>List length→dim (list name),{column,row}→dim (matrix name) |
| | | | 4 | fill ( | Satisfies list element using specified value | fill(value, matrix name)<br>fill(value, list name) |
| | | | 5 | seq ( | Creates a sequential list using the value obtained by inputting equation and changing the variable in the specified range | seq(equation, initial value,end value [,increment]) |
| | | | 6 | cumul | Creates cumulative list and cumulative matrix (cumulative list with all lines as one list) | cumul list<br>cumul matrix name<br>cumul list name |
| | | | 7 | df_list | Creates a differential list between list elements | df_list list name or list |
| | | | 8 | augment ( | Creates a list that augments two lists | augment(C,D)<br>C and D are lists, matrix names or list names |
| | | | 9 | list→mat ( | Satisfies matrix in line units from the individually specified list elements | list→mat(list or list name 1,...,matrix name) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | LIST | A OPE | 0 | mat→list ( | Satisfies individual list from individual line elements of matrices subordinate list name n | mat→list(matrix name,list or list name 1...,list or list name n), mat → list(matrix name,line number,list number) |
| | | B MATH | 1 | min ( | Finds the smallest value from list, list element, numerical value, etc. | min (A,B) or min (list) |
| | | | 2 | max ( | Find the largest value from list, list element, numerical value, etc. | max (A, B) or max (list) |
| | | | 3 | mean ( | Finds the mean from list element (applicable only in list calculation) | mean (list [, frequency list of data]) |
| | | | 4 | median ( | Finds the median of elements within a list (applicable only in list calculation) | median(list [, frequency list of data]) |
| | | | 5 | sum ( | Finds the total of list elements from beginning to end<br>Finds the total of sequential elements from beginning to end | sum(list [,initial value,end value])<br>sum(seq(equation, beginning value,end value [,increment])) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | LIST | B MATH | 6 | prod ( | Finds the cumulative sum of list elements from beginning to end<br>Finds the total of sequential elements from beginning to end | prod(list [,initial value,end value])<br>prod(seq(equation, beginning value,end value [,increment])) |
| | | | 7 | stdDv ( | Finds the standard deviation of elements within a list (applicable only in list calculation) | stdDv(list [,frequency list of data]) |
| | | | 8 | varian ( | Finds variance of elements within a list (applicable only in list calculation) | varian(list [,frequency list of data]) |
| | | C L_DATA | 1 | StoLD | Stores list database | StoLD number (0to9, LD0toLD9) |
| | | | 2 | RclLD | Recalls list database | RclLD number (0to9, LD0toLD9) |
| | STAT | A EDIT | | | Edit STAT list | |
| | | B OPE | 1 | sortA ( | Sorts elements of STAT list name in ascending order | sortA(list name)<br>sortA(list name, subordinate list name 1,...subordinate list n) |
| | | | 2 | sortD ( | Sorts elements of STAT list name in descending order | sortD(list name)<br>sortD(list name, subordinate list name 1,...subordinate list n) |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| | STAT | B OPE | 3 | SetList | Specifies the arrangement of list used in the statistic editor. | SetList<br>SetList list name1 [,list name2,...] |
| | | | 4 | ClrList | Clears multiple list data | ClrList list name 1 [,list name 2,...] |
| | | C CALC | 1 | 1_Stats | Executes 1-variable statistic analysis | 1_Stats [X list name [,frequency]] |
| | | | 2 | 2_Stats | Executes 2-variable statistic analysis | 2_Stats [X list name,Y list name[, frequency]] |
| | | | 3 | ANOVA ( | Executes one-way scatter analysis | ANOVA(list name 1, list name 2[,...]) |
| | | D REG | 01 | Med_Med | Executes regression calculation using the median-median method | Med_Med (X list name, Y list name [,frequency list of data] [,equation name for storing]) |
| | | | 02 | Rg_ax+b | Executes linear regression calculation (regression equation: ax + b) | Rg_ax+b (X list name, Y list name [,frequency list of data] [,equation name for storing]) |
| | | | 03 | Rg_a+bx | Executes linear regression calculation (regression equation: a + bx) | Rg_a+bx (X list name, Y list name [,frequency list of data] [,equation name for storing]) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT | D REG | 04 | Rg_$x^2$ | Executes quadratic regression calculation (regression equation: $ax^2 + bx + c$) | Rg_$x^2$ (X list name, Y list name [,frequency list of data] [,equation name for storing]) |
| | | | 05 | Rg_$x^3$ | Executes cubic regression calculation (regression equation: $ax^3+bx^2+cx+d$) | Rg_$x^3$ (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 06 | Rg_$x^4$ | Executes quatric regression calculation (regression equation: $ax^4+bx^3+cx^2+dx+e$) | Rg_$x^4$ (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 07 | Rg_ln | Executes natural logarithm regression calculation (regression equation: a+blnX) | Rg_ln (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 08 | Rg_log | Executes logarithm regression calculation using base 10 (regression equation: a+blogx) | Rg_log (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 09 | Rg_$ab^x$ | Executes exponential regression calculation (regression equation: $ab^x$) | Rg_$ab^x$ (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT | D REG | 10 | Rg_ae$^{bx}$ | Executes exponential regression calculation (regression equation: ae$^{bx}$) | Rg_ae$^{bx}$ (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 11 | Rg_x$^{-1}$ | Executes reciprocal regression calculation (regression equation: a+bx$^{-1}$) | Rg_x$^{-1}$ (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 12 | Rg_ax$^{b}$ | Executes power regression calculation (regression equation: ax$^{b}$) | Rg_ax$^{b}$ (Xlist name,Ylist name [,frequency list of data] [,equation name for storing]) |
| | | | 13 | Rg_logistic | Executes logistic regression calculation (regression equation: c/(1+ae$^{-bx}$) | Rg_logistic (Xlist name, Ylist name [, frequency list of data], [equation name for storing]) |
| | | | 14 | Rg_sin | Executes sine regression calculation (regression equation: a•sin (bx+c)+d)*1<br>Note. The sin regression procedure requires complex calculations and might lengthen operation time. | Rg_sin ([iterations,] Xlist, Ylist [, frequency list of data] [, period][, equation variable name]) |
| | | | 15 | x’ | Only for previously executed regression equation excluding 2nd, 3rd, 4th degree polynomial regressions, sin regression and logistic regression :<br>Calculates the estimated value of X obtained by giving numerical values to x and y | A x’ |

*1 The number of default iterations is 3. The user may specify up to 25 iterations.
To obtain a more accurate fit: set number of iterations to 25, set the period to 2π/b, where b = result of the previous calculation.

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | minor-category | Name | | |
| | STAT | D REG | 16 | y’ | Only for previously executed regression equation excluding 2nd, 3rd, 4th degree polynomial regressions, sin regression and logistic regression : Calculates the estimated value of Y obtained by giving numerical values to x and y | A y’ |
| | | E TEST | 01 | $\chi^2$ test | Tests the square of a two-dimensional table | |
| | | | 02 | Ftest 2samp | Two σs are compared and tested. | |
| | | | 03 | Ttest 1samp | Tests one μ when σ is unknown | |
| | | | 04 | Ttest 2samp | Compares and tests two μs when σ is unknown | |
| | | | 05 | Ttest Linreg | Tests regression slope and ρ | |
| | | | 06 | Tint1samp | Calculates confidence bound of one μ when σ is unknown | |
| | | | 07 | Tint2samp | Calculates confidence bound of two μs when σ is unknown | |
| | | | 08 | Ztest 1samp | Tests one μ when σ is known | |
| | | | 09 | Ztest 2samp | Compares and tests two μs when σ is known | |
| | | | 10 | Ttest 1prop | Tests one comparison | |
| | | | 11 | Ztest 2prop | Tests two comparisons | |
| | | | 12 | Zint1samp | Calculates confidence bound of one μ when σ is known | |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT | E TEST | 13 | Zint2samp | Calculates confidence bound of two μs, when σ is known | |
| | | | 14 | Zint1prop | Outputs the confidence bound of one ratio | |
| | | | 15 | Zint2prop | Outputs the confidence bound of two ratios | |
| | | | 16 | InputList | Specifies list input of statistical data values (list input) | |
| | | | 17 | InputStats | Specifies value input of statistical data value (parameter input) | |
| | | F DISTRI | 01 | pdfnorm ( | Calculates normal distribution probability density (list not possible) | pdfnorm (value [,mean, standard deviation]) |
| | | | 02 | cdfnorm( | Calculates normal distribution probability (list not possible) | cdfnorm(lower limit,upper limit [,mean, standard deviation]) |
| | | | 03 | InvNorm ( | Calculates inverse function of normcdf (list not possible) | InvNorm(surface area [,mean, standard deviation]) |
| | | | 04 | pdfT ( | Calculates t distribution probability density (list not possible) | pdfT(value,degree of freedom) |
| | | | 05 | cdfT ( | Calculates t distribution probability (list not possible) | cdfT(lower limit, upper limit, degree of freedom) |
| | | | 06 | pdf$\chi^2$ ( | Calculates $\chi^2$ distribution probability density (list not possible) | pdf$\chi^2$(value, degree of freedom) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT | F DISTRI | 07 | cdf$\chi^2$ ( | Calculates $\chi^2$ distribution probability (list not possible) | cdf$\chi^2$(lower limit, upper limit,degree of freedom) |
| | | | 08 | pdfF ( | Calculates F distribution probability density (list not possible) | pdfF(value,degree of freedom of numerator,degree of freedom of denominator) |
| | | | 09 | cdfF ( | Calculates F distribution probability (list not possible) | cdfF(lower limit, upper limit [,degree of freedom of numerator, degree of freedom of denominator]) |
| | | | 10 | pdfbin ( | Calculates binary distribution probability density<br>List not possible (list possible only for successful numbers) | pdfbin(trial number,success probability [,success number]) |
| | | | 11 | cdfbin ( | Calculates binary distribution probability<br>List not possible (list possible only for successful numbers) | cdfbin(trial number, success probability [,success number]) |
| | | | 12 | pdfpoi ( | Calculates Poisson distribution probability density | pdfpoi(mean,x) |
| | | | 13 | cdfpoi ( | Calculates Poisson distribution Probability | cdfpoi(mean,x) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT | F DISTRI | 14 | pdfgeo ( | Calculates geometric distribution probability density | pdfgeo(success probability,x) |
| | | | 15 | cdfgeo ( | Calculates geometric distribution probability | cdfgeo(success probability,x) |
| | DRAW | A DRAW | 1 | ClrDraw | Clears drawings and graphs of drawn elements | ClrDraw |
| | | | 2 | Line ( | Draws a straight line on a graph<br>Clears a straight line on a graph (list not possible) | Line(start point x, start point y, end point x, end point y)<br>Line(start point x, start point y, end point x, end point y,0) |
| | | | 3 | H_line | Draws a horizontal line on graph<br>(list not possible) | H_line y coordinate |
| | | | 4 | V_line | Draws a vertical line on graph<br>(list not possible) | V_line x coordinate |
| | | | 5 | T_line ( | Draws a tangent line during x on graph<br>(list not possible) | T_line(equation, value of x) |
| | | | 6 | Draw | Draws equations and functions | Draw numerical equation |
| | | | 7 | Shade ( | Shades an area between specified functions | Shade(lower limit,upper limit [,begin,end]) |
| | | | 8 | DrawInv | Draws a inverse function (draws a graph symmetrical to axis of graph “Y=X”) | DrawInv numerical equation |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | DRAW | A DRAW | 9 | Circle ( | Draws a circle on screen | Circle(x coord.,y coord.,radius) |
| | | | 0 | Text ( | Draws text on screen | Text (column, line, ”characters to be displayed”) |
| | | B POINT | 1 | PntON ( | Draws a point on screen | PntON(x coord.,y coord.[,mark value]) |
| | | | 2 | PntOFF ( | Clears a point on screen | PntOFF(x coord.,y coord.[,mark value]) |
| | | | 3 | PntCHG( | Draws a point when there none, and clears a point when there is | PntCHG(x coord.,y coord.) |
| | | | 4 | PxlON ( | Draws a dot in the specified column and row (dot coordinates) on screen | PxlON (column,row) |
| | | | 5 | PxlOFF ( | Clears a dot in the specified column and row (dot coordinates) on screen | PxlOFF (column,row) |
| | | | 6 | PxlCHG ( | Changes the condition of dot (flashing/not flashing) in the specified column and row (dot coordinates) on screen | PxlCHG (column,row) |
| | | | 7 | PxlTST ( | 1 is returned if there is a dot on the specified column and row and 0 is return when there not | PxlTST (column,row) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | DRAW | C ON/ OFF | 1 | DrawON | Make graph equations valid by equation units | DrawON [numerical equation No1, Numerical equation No2,...,] -All equations are selected when numerical equation No is omitted |
| | | | 2 | DrawOFF | Make graph equations invalid by equation units | DrawOFF[numerical equation No1, Numerical equation No2,...,] -All equations are unselected when numerical equation No is omitted |
| | | D LINE | | | Set graph line type | Press ENTER to open line type selection screen |
| | | E G_DATA | 1 | StoGD | Stores graph database | StoGD number (0 to 9, GD0 to GD9) |
| | | | 2 | RclGD | Recalls graph database | RclGD number (0 to 9, GD0 to GD9) |
| | | F PICT | 1 | StoPict | Stores graph screen (picture) | StoPict number (0 to 9, Pict 0 to Pict 9) |
| | | | 2 | RclPict | Recalls graph screen (picture) | RclPict number (0 to 9, Pict 0 to Pict 9) |
| | | G SHADE | 1 | SET | Shade space between functions | SET |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| | DRAW | G SHADE | 2 | INITIAL | Return graph screen to its default setting (clear shade) | INITIAL |
| | ZOOM | A ZOOM | 1 | Auto | Automatic scale setting (relationship of Ymin and Ymax is adjusted to the relationship of Xmin and Xmax) | Auto |
| | | | 2 | Box | Draws a box then defines display screen | Box |
| | | | 3 | In | Enlarges graph display with the cursor as the center | In |
| | | | 4 | Out | Reduces graph display with the cursor as the center | Out |
| | | | 5 | Default | Draws graph by setting to the standard screen variable (default setting values) | Default |
| | | | 6 | Square | Draws graph by making the pixel size of X and Y axis equal | Square |
| | | | 7 | Dec | Draws graph by setting $\Delta X$ and $\Delta Y$ to 0.1 | Dec |
| | | | 8 | Int | Draws graph by setting $\Delta X$ and $\Delta Y$ to 1 | Int |
| | | | 9 | Stat | Draws graph by displaying all points of statistical data | Stat |
| | | B FACTOR | | | Set magnification of X and Y axis by manual entry | Press ENTER to open magnification input screen |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | ZOOM | C POWER | 1 | $X^2$ | Draws graph using screen settings most suited for drawing "$Y=X^2$" | $X^2$ |
| | | | 2 | $X^{-1}$ | Draws graph using screen settings most suited for drawing "$Y=X^{-1}$" | $X^{-1}$ |
| | | | 3 | $\sqrt{x}$ | Draws graph using screen settings most suited for drawing "$Y=\sqrt{x}$" | $\sqrt{x}$ |
| | | D EXP | 1 | $10^X$ | Draws graph using screen settings most suited for drawing "$Y=10^X$" | $10^X$ |
| | | | 2 | $e^X$ | Draws graph using screen settings most suited for drawing "$Y=e^X$" | $e^X$ |
| | | | 3 | log x | Draws graph using screen settings most suited for drawing "Y=log x" | log x |
| | | | 4 | In x | Draws graph using screen settings most suited for drawing "Y=In x" | In x |
| | | E TRIG | 1 | sin x | Draws graph using screen settings most suited for drawing "Y=sin x" | sin x |
| | | | 2 | cos x | Draws graph using screen settings most suited for drawing "Y=cos x" | cos x |
| | | | 3 | tan x | Draws graph using screen settings most suited for drawing "Y=tan x" | tan x |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | ZOOM | E TRIG | 4 | $\sin^{-1} x$ | Draws graph using screen settings most suited for drawing "$Y=\sin^{-1} x$" | $\sin^{-1} x$ |
| | | | 5 | $\cos^{-1} x$ | Draws graph using screen settings most suited for drawing "$Y=\cos^{-1} x$" | $\cos^{-1} x$ |
| | | | 6 | $\tan^{-1} x$ | Draws graph using screen settings most suited for drawing "$Y=\tan^{-1} x$" | $\tan^{-1} x$ |
| | | F HYP | 1 | sinh x | Draws graph using screen settings most suited for drawing "Y=sinh x" | sinh x |
| | | | 2 | cosh x | Draws graph using screen settings most suited for drawing "Y=cosh x" | cosh x |
| | | | 3 | tanh x | Draws graph using screen settings most suited for drawing "Y=tanh x" | tanh x |
| | | | 4 | $\sinh^{-1} x$ | Draws graph using screen settings most suited for drawing "$Y=\sinh^{-1} x$" | $\sinh^{-1} x$ |
| | | | 5 | $\cosh^{-1} x$ | Draws graph using screen settings most suited for drawing "$Y=\cosh^{-1} x$" | $\cosh^{-1} x$ |
| | | | 6 | $\tanh^{-1} x$ | Draws graph using screen settings most suited for drawing "$Y=\tanh^{-1} x$" | $\tanh^{-1} x$ |
| | | G STO | 1 | StoWin | Stores WINDOW information | StoWin |
| | | H RCL | 1 | RclWin | Recalls stored WINDOW information | RclWin |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | ZOOM | H RCL | 2 | PreWin | Draws graph using WINDOW information prior to executing the ZOOM function | PreWin |
| | CALC | A CALC | 1 | Value | Find function value Y for value X | Value |
| | (only value can be selected when coordinate system is Polar, Param or Seq) | | | | | |
| | | | 2 | Intsct | Finds the intersection of two functions | Intsct |
| | | | 3 | Minimum | Finds the smallest value of a function | Minimum |
| | | | 4 | Maximum | Finds the largest value of a function | Maximum |
| | | | 5 | X_Incpt | Finds the intersecting point of function and X axis | X_Incpt |
| | | | 6 | Y_Incpt | Finds the intersecting point of function and Y axis | Y_Incpt |
| | | | 7 | Inflec | Finds inflection point of a function | Inflec |
| | FINANCE | A SOLVER | | | Set the T.V.M. solver execution mode | Press ENTER to display the SOLVER screen |
| | | B CALC | 01 | slv_pmt | Calculates individual payments | slv_pmt [(N, I%, PV, FV, P/Y, C/Y)] |
| | | | 02 | slv_I% | Calculates annual interest rate | slv_I% [(N, PV, PMT, FV, P/Y, C/Y)] |
| | | | 03 | slv_PV | Calculates present value | slv_PV [(N, I%, PMT, FV, P/Y, C/Y)] |
| | | | 04 | slv_N | Calculates number of payments | slv_N [(I%, PV, PMT, FV, P/Y, C/Y)] |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | FINANCE | B CALC | 05 | slv_FV | Calculates total of principal and interest (future value) | slv_FV [(N, I%, PV, PMT, P/Y, C/Y)] |
| | | | 06 | Npv ( | Calculates net present value (calculates the total present value for cash inflow and outflow) | Npv(interest rate, initial investment, list of collected investments [,frequency list of list on the right]) |
| | | | 07 | Irr ( | Calculates investment revenue rate | Irr(initial investment, list of collected investments [,frequency list of list on the right]) |
| | | | 08 | Bal ( | Calculates payment balance | Bal(number of payments [,decimal place for round calculation]) |
| | | | 09 | ΣPrn | Calculates principal sum included in payment balance | ΣPrn(initial payment number, end payment number [,decimal place for round calculation]) |
| | | | 10 | ΣInt | Calculates the total sum of interest included in payment balance | ΣInt(initial payment number, end payment number [,decimal place for round calculation]) |
| | | | 11 | →Apr ( | Converts annual effective rate to nominal interest rate | →Apr(annual effective rate, number of settled accounts) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | FINANCE | B CALC | 12 | →Eff ( | Converts nominal interest rate to annual effective rate | →Eff(nominal interest rate, number of settled accounts) |
| | | | 13 | days ( | Calculates number of days (from the initial day to last day) | days(initial month day year, last month day year) |
| | | C PERIOD | 1 | PmtEnd | Specifies that there are payments at the end of indi vidual payment period | PmtEnd |
| | | | 2 | PmtBegin | Specifies that there are payments at the beginning of individual payment period | PmtBegin |
| | | D VARS | 1 | N | Total number of payments | N |
| | | | 2 | I% | Annual interest | I% |
| | | | 3 | PV | Present value | PV |
| | | | 4 | PMT | Payment amount for each payment period | PMT |
| | | | 5 | FV | Future value | FV |
| | | | 6 | P/Y | Number of payments per year | P/Y |
| | | | 7 | C/Y | Compounding periods per year | C/Y |
| * | PRGM COM | A PRGM | 1 | Print | Display command | Print ”character string<br>Print variable name |
| | | | 2 | ” | Enclosure for print charac-ters of the Print command | ” |
| | | | 3 | Input | Input request command | Input variable name |
| | | | 4 | Wait | Wait command | Wait wait time (in seconds)<br>Wait (wait until a key is pressed) |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| * | PRGM COM | A PRGM | 5 | Rem | Comment command | Rem character string |
| | | | 6 | End | End command | End |
| | | B BRNCH | 1 | Label | Label definition command | Label character string (under 10 characters) |
| | | | 2 | Goto | Jump command | Goto label name |
| | | | 3 | If | Condition diversion command | If condition Goto label name |
| | | | 4 | Gosub | Subroutine call command | Gosub label name |
| | | | 5 | Return | Return command | Return |
| | | C SCRN | 1 | ClrT | Clears program text screen | ClrT |
| | | | 2 | ClrG | Clears graph of program being executed | ClrG |
| | | | 3 | DispT | Displays program text screen | DispT |
| | | | 4 | DispG | Displays present graph | DispG |
| | | D I/O | 1 | Get | Receives command for variable contents | Get variable name |
| | | | 2 | Send | Sends command for variable contents | Send variable name |
| | | E COORD | 1 | Rect | Sets rectangular graph mode | Rect |
| | | | 2 | Param | Sets parametric variable graph mode | Param |
| | | | 3 | Polar | Sets polar coordinate graph mode | Polar |
| | | | 4 | Web | Sets COB.Web graph mode | Web |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | PRGM COM | E COORD | 5 | Time | Sets axis for sequence graphing (sets n to X axis and u(*n*), v(*n*) and w(*n*) to Y axis) | Time |
| | | | 6 | uv | Sets axis for sequence graphing (sets u(*n*) to X axis and v(*n*) to Y axis) | uv |
| | | | 7 | uw | Sets axis for sequence graphing (sets u(*n*) to X axis and w(*n*) to Y axis) | uw |
| | | | 8 | vw | Sets axis for sequence graphing (sets v(*n*) to X axis and w(*n*) to Y axis) | vw |
| | | F FORM | 1 | RectCursor | Sets coordinate display format for rectangular graphs | Rect Cursor |
| | | | 2 | Polar Cursor | Sets coordinate display format for polar graphs | Polar Cursor |
| | | | 3 | ExprON | Displays specified graph on-screen | ExprON |
| | | | 4 | ExprOFF | Deletes specified graph from screen | ExprOFF |
| | | | 5 | Y'ON | Displays graph slope (dy/dx) on screen | Y'ON |
| | | | 6 | Y'OFF | Clears graph slope (dy/dx) from screen | Y'OFF |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| * | PRGM COM | F FORM | 7 | Connect | Specifies connect plot mode. Reset all graph line type to "–" | Connect |
| | | | 8 | Dot | Specifies dot plot mode. Reset all graph line type to "…" | Dot |
| | | | 9 | Sequen | Specifies sequential graphing mode (Draws one graph at a time) | Sequen |
| | | | 0 | Simul | Specifies simultaneous graphing mode (draws multiple graphs at one time) | Simul |
| | | G S-PLOT | 1 | Plt1( | Specifies statistic plot (Plt1) | "Plt1 (type, Xlist [, Freq])" for HIST, B. L., N.P., N.D., Box, and MBox. "Plt1 (type, Xlist, Ylist [, Freq])" for S.D. and XYLINE. |
| | | | 2 | Plt2( | Specifies statistic plot (Plt2) | |
| | | | 3 | Plt3( | Specifies statistic plot (Plt3) | |
| | | H COPY | 1 | StoLine | Stores one line of a program | StoLine |
| | | | 2 | RclLine | Recall one line of a program | RclLine |
| | VARS | A EQVARS | | | Displays the graph equation variable selection screen | Press ENTER to display the equation selection screen |
| | | B WINDOW | | | Displays the WINDOW variable selection screen | Press ENTER to display the WINDOW information selection screen |
| | | C STOWIN | | | Displays ZOOM variable selection screen stored with ZOOM | Press ENTER to display the ZOOM parameter selection screen |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | VARS | D<br>L_DATA | 1 | L_Data1 | Selects list data 1 then transfers data to screen | StoLD L_Data1<br>RclLD L_Data1 |
| | | | 2 | L_Data2 | Selects list data 2 then transfers data to screen | StoLD L_Data2<br>RclLD L_Data2 |
| | | | 3 | L_Data3 | Selects list data 3 then transfers data to screen | StoLD L_Data3<br>RclLD L_Data3 |
| | | | 4 | L_Data4 | Selects list data 4 then transfers data to screen | StoLD L_Data4<br>RclLD L_Data4 |
| | | | 5 | L_Data5 | Selects list data 5 then transfers data to screen | StoLD L_Data5<br>RclLD L_Data5 |
| | | | 6 | L_Data6 | Selects list data 6 then transfers data to screen | StoLD L_Data6<br>RclLD L_Data6 |
| | | | 7 | L_Data7 | Selects list data 7 then transfers data to screen | StoLD L_Data7<br>RclLD L_Data7 |
| | | | 8 | L_Data8 | Selects list data 8 then transfers data to screen | StoLD L_Data8<br>RclLD L_Data8 |
| | | | 9 | L_Data9 | Selects list data 9 then transfers data to screen | StoLD L_Data9<br>RclLD L_Data9 |
| | | | 0 | L_Data0 | Selects list data 0 then transfers data to screen | StoLD L_Data0<br>RclLD L_Data0 |
| | | E<br>G_DATA | 1 | G_Data1 | Selects graph data 1 then transfers data to screen | StoGD G_Data1<br>RclGD G_Data1 |
| | | | 2 | G_Data2 | Selects graph data 2 then transfers data to screen | StoGD G_Data2<br>RclGD G_Data2 |
| | | | 3 | G_Data3 | Selects graph data 3 then transfers data to screen | StoGD G_Data3<br>RclGD G_Data3 |
| | | | 4 | G_Data4 | Selects graph data 4 then transfers data to screen | StoGD G_Data4<br>RclGD G_Data4 |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | VARS | E G_DATA | 5 | G_Data5 | Selects graph data 5 then transfers data to screen | StoGD G_Data5<br>RclGD G_Data5 |
| | | | 6 | G_Data6 | Selects graph data 6 then transfers data to screen | StoGD G_Data6<br>RclGD G_Data6 |
| | | | 7 | G_Data7 | Selects graph data 7 then transfers data to screen | StoGD G_Data7<br>RclGD G_Data7 |
| | | | 8 | G_Data8 | Selects graph data 8 then transfers data to screen | StoGD G_Data8<br>RclGD G_Data8 |
| | | | 9 | G_Data9 | Selects graph data 9 then transfers data to screen | StoGD G_Data9<br>RclGD G_Data9 |
| | | | 0 | G_Data0 | Selects graph data 0 then transfers data to screen | StoGD G_Data0<br>RclGD G_Data0 |
| | | F PICTUR | 1 | Pict1 | Selects picture data 1 then transfers data to screen | StoPict Pict1<br>RclPict Pict1 |
| | | | 2 | Pict2 | Selects picture data 2 then transfers data to screen | StoPict Pict2<br>RclPict Pict2 |
| | | | 3 | Pict3 | Selects picture data 3 then transfers data to screen | StoPict Pict3<br>RclPict Pict3 |
| | | | 4 | Pict4 | Selects picture data 4 then transfers data to screen | StoPict Pict4<br>RclPict Pict4 |
| | | | 5 | Pict5 | Selects picture data 5 then transfers data to screen | StoPict Pict5<br>RclPict Pict5 |
| | | | 6 | Pict6 | Selects picture data 6 then transfers data to screen | StoPict Pict6<br>RclPict Pict6 |
| | | | 7 | Pict7 | Selects picture data 7 then transfers data to screen | StoPict Pict7<br>RclPict Pict7 |
| | | | 8 | Pict8 | Selects picture data 8 then transfers data to screen | StoPict Pict8<br>RclPict Pict8 |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | VARS | F PICTUR | 9 | Pict9 | Selects Picture data 9 then transfers data to screen | StoPict Pict9<br>RclPict Pict9 |
| | | | 0 | Pict0 | Selects Picture data 0 then transfers data to screen | StoPict Pict0<br>RclPict Pict0 |
| | | G TABLE | 1 | TBLStrt | Selects the default setting value of table and transfers it to screen | TBLStrt variable name |
| | | | 2 | TBLStep | Selects table increment and transfers it to screen | TBLStep variable name |
| | | | 3 | TBLList | Selects the variable value list for the present table and transfers it to screen | TBLList list name |
| | | H STAT | | | Displays the statistic function selection screen | Press ENTER to display statistic function graph screen |
| * | EQVAR | A XY | 1 | Y1 | Selects graph equation Y1 then transfers it to screen | Y1 |
| | | | 2 | Y2 | Selects graph equation Y2 then transfers it to screen | Y2 |
| | | | 3 | Y3 | Selects graph equation Y3 then transfers it to screen | Y3 |
| | | | 4 | Y4 | Selects graph equation Y4 then transfers it to screen | Y4 |
| | | | 5 | Y5 | Selects graph equation Y5 then transfers it to screen | Y5 |
| | | | 6 | Y6 | Selects graph equation Y6 then transfers it to screen | Y6 |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | EQVAR | A XY | 7 | Y7 | Selects graph equation Y7 then transfers it to screen | Y7 |
| | | | 8 | Y8 | Selects graph equation Y8 then transfers it to screen | Y8 |
| | | | 9 | Y9 | Selects graph equation Y9 then transfers it to screen | Y9 |
| | | | 0 | Y0 | Selects graph equation Y0 then transfers it to screen | Y0 |
| | | B XYT | 01 | X1T | Selects graph equation X1T then transfers it to screen | X1T |
| | | | 02 | Y1T | Selects graph equation Y1T then transfers it to screen | Y1T |
| | | | 03 | X2T | Selects graph equation X2T then transfers it to screen | X2T |
| | | | 04 | Y2T | Selects graph equation Y2T then transfers it to screen | Y2T |
| | | | 05 | X3T | Selects graph equation X3T then transfers it to screen | X3T |
| | | | 06 | Y3T | Selects graph equation Y3T then transfers it to screen | Y3T |
| | | | 07 | X4T | Selects graph equation X4T then transfers it to screen | X4T |
| | | | 08 | Y4T | Selects graph equation Y4T then transfers it to screen | Y4T |
| | | | 09 | X5T | Selects graph equation X5T then transfers it to screen | X5T |
| | | | 10 | Y5T | Selects graph equation Y5T then transfers it to screen | Y5T |
| | | | 11 | X6T | Selects graph equation X6T then transfers it to screen | X6T |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| * | EQVAR | B XYT | 12 | Y6T | Selects graph equation Y6T then transfers it to screen | Y6T |
| | | C Rθ | 1 | R1 | Selects graph equation R1 then transfers it to screen | R1 |
| | | | 2 | R2 | Selects graph equation R2 then transfers it to screen | R2 |
| | | | 3 | R3 | Selects graph equation R3 then transfers it to screen | R3 |
| | | | 4 | R4 | Selects graph equation R4 then transfers it to screen | R4 |
| | | | 5 | R5 | Selects graph equation R5 then transfers it to screen | R5 |
| | | | 6 | R6 | Selects graph equation R6 then transfers it to screen | R6 |
| * | WINVAR | A XY | 1 | Xmin | Specifies the smallest value of the X axis of a graph screen then transfers it to screen | Xmin |
| | | | 2 | Xmax | Specifies the largest value of the X axis of a graph screen then transfers it to screen | Xmax |
| | | | 3 | Xscl | Specifies the scale spacing of the X axis of a graph screen then transfers it to screen | Xscl |
| | | | 4 | Ymin | Specifies the smallest value of the Y axis of a graph screen then transfers it to screen | Ymin |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | WINVAR | A XY | 5 | Ymax | Specifies the largest value of the Y axis of a graph screen then transfers it to screen | Ymax |
| | | | 6 | Yscl | Specifies the scale spacing of the Y axis of a graph screen then transfers it to screen | Yscl |
| | | | 7 | X_Fact | Specifies the X axis direction magnification during ZOOM IN/OUT then transfers it to screen | X_Fact |
| | | | 8 | Y_Fact | Specifies the Y axis direction magnification during ZOOM IN/OUT then transfers it to screen | Y_Fact |
| | | B T | 1 | Tmin | Specifies the smallest value of graph screen T then transfers it to screen | Tmin |
| | | | 2 | Tmax | Specifies the largest value of T then transfers it to screen | Tmax |
| | | | 3 | Tstep | Specifies the increment of T then transfers it to screen | Tstep |
| | | C θ | 1 | θmin | Specifies the smallest value of θ then transfers it to screen | θmin |
| | | | 2 | θmax | Specifies the largest value of θ then transfers it to screen | θmax |
| | | | 3 | θstep | Specifies the increment of θ then transfers it to screen | θstep |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | WINVAR | D SEQ | 1 | *n*Min | Specifies the smallest value of a numerical equation graph to be evaluated then displays it on screen | *n*Min |
| | | | 2 | *n*Max | Specifies the largest value of a numerical equation graph to be evaluated then displays it on screen | *n*Max |
| | | | 3 | u(*n*Min) | Specifies the sequence value of u(*n*Min) then displays it on screen | u(*n*Min) |
| | | | 4 | v(*n*Min) | Specifies the sequence value of v(*n*Min) then displays it on screen | v(*n*Min) |
| | | | 5 | w(*n*Min) | Specifies the sequence value of w(*n*Min) then displays it on screen | w(*n*Min) |
| | | | 6 | PlotStart | Specifies the first sequence number to be plotted for sequence graphs then displays in on screen | PlotStart |
| | | | 7 | PlotStep | Specifies the increment of a sequence graph then displays it on screen | PlotStep |
| * | STOWIN VAR | A STOXY | 1 | Zm_Xmin | Specifies Xmin prior to executing the ZOOM function then displays it on screen | Zm_Xmin |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STOWIN VAR | A STOXY | 2 | Zm_Xmax | Specifies Xmax prior to executing the ZOOM function then displays it on screen | Zm_Xmax |
| | | | 3 | Zm_Xscl | Specifies Xscl prior to executing the ZOOM function then displays it on screen | Zm_Xscl |
| | | | 4 | Zm_Ymin | Specifies Ymin prior to executing the ZOOM function then displays it on screen | Zm_Ymin |
| | | | 5 | Zm_Ymax | Specifies Ymax prior to executing the ZOOM function then displays it on screen | Zm_Ymax |
| | | | 6 | Zm_Yscl | Specifies Yscl prior to executing the ZOOM function then displays it on screen | Zm_Yscl |
| | | B STOT | 1 | Zm_Tmin | Specifies Tmin prior to executing the ZOOM function then displays it on screen | Zm_Tmin |
| | | | 2 | Zm_Tmax | Specifies Tmax prior on executing the ZOOM function then displays it on screen | Zm_Tmax |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STOWIN VAR | B STOT | 3 | Zm_Tstp | Specifies Tstep prior to executing the ZOOM function then displays it on screen | Zm_Tstp |
| | | C STOθ | 1 | Zm_θmin | Specifies θmin prior to executing the ZOOM function then displays it on screen | Zm_θmin |
| | | | 2 | Zm_θmax | Specifies θmax prior to executing the ZOOM function then displays it on screen | Zm_θmax |
| | | | 3 | Zm_θstp | Specifies θstep prior to executing the ZOOM function then displays it on screen | Zm_θstp |
| | | D STOSEQ | 1 | Zm_*n*Min | Specifies *n*Min prior to executing the ZOOM function then displays it on screen | Zm_*n*Min |
| | | | 2 | Zm_*n*Max | Specifies *n*Max prior to executing the ZOOM function then displays it on screen | Zm_*n*Max |
| | | | 3 | Zm_u(*n*Min) | Specifies u(*n*Min) prior to executing the ZOOM function then displays it on screen | Zm_u(*n*Min) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STOWIN VAR | D STOSEQ | 4 | Zm_v(*n*Min) | Specifies v(*n*Min) prior to executing the ZOOM function then displays it on screen | Zm_v(*n*Min) |
| | | | 5 | Zm_w(*n*Min) | Specifies w(*n*Min) prior to executing the ZOOM function then displays it on screen | Zm_w(*n*Min) |
| | | | 6 | Zm_PltStart | Specifies the PlotStart value prior to executing the ZOOM function then displays it on screen | Zm_PltStart |
| | | | 7 | Zm_PltStp | Specifies the PlotStp value prior to executing the ZOOM function then displays it on screen | Zm_PltStp |
| * | STAT VAR | A XY | 01 | *n* | Specifies statistical sample number then displays it on screen | *n* |
| | | | 02 | $\bar{x}$ | Specifies mean of x then displays it on screen | $\bar{x}$ |
| | | | 03 | sx | Specifies sample standard deviation of x then displays it on screen | sx |
| | | | 04 | σx | Specifies population standard deviation of x then displays it on screen | σx |
| | | | 05 | xmin | Specifies smallest value of x then displays it on screen | xmin |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STAT VAR | A XY | 06 | xmax | Specifies largest value of x then displays it on screen | xmax |
| | | | 07 | Σx | Specifies sum of x then displays it on screen | Σx |
| | | | 08 | $\Sigma x^2$ | Specifies sum of squares of x then displays it on screen | $\Sigma x^2$ |
| | | | 09 | Σxy | Specifies cumulative sum of x,y then displays it on screen | Σxy |
| | | | 10 | $\overline{y}$ | Specifies mean of y then displays it on screen | $\overline{y}$ |
| | | | 11 | sy | Specifies sample standard deviation of y then displays it on screen | sy |
| | | | 12 | σy | Specifies population standard deviation of y then displays it on screen | σy |
| | | | 13 | ymin | Specifies smallest value of y then displays it on screen | ymin |
| | | | 14 | ymax | Specifies largest value of sample y then displays it on screen | ymax |
| | | | 15 | Σy | Specifies sum of y then displays it on screen | Σy |
| | | | 16 | $\Sigma y^2$ | Specifies sum of squares of y then displays it on screen | $\Sigma y^2$ |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STAT VAR | B REGEQN | 1 | RegEqn | Displays obtained regression equation | RegEqn |
| | | | 2 | a | Specifies linear regression coefficient a then transfers it to screen | a |
| | | | 3 | b | Specifies linear regression coefficient b then transfers it to screen | b |
| | | | 4 | c | Specifies linear regression coefficient c then transfers it to screen | c |
| | | | 5 | d | Specifies linear regression coefficient d then transfers it to screen | d |
| | | | 6 | e | Specifies linear regression coefficient e then transfers it to screen | e |
| | | | 7 | r | Specifies coefficient of correlation r then transfers it to screen | r |
| | | | 8 | $r^2$ | Specifies coefficient of correlation $r^2$ then transfers it to screen | $r^2$ |
| | | | 9 | $R^2$ | Specifies coefficient of correlation $R^2$ then transfers it to screen | $R^2$ |
| | | | 0 | resid | Recalls and displays list of automatic residuals of regression calculations. | resid |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STAT VAR | C POINTS | 1 | x1 | Median summary point of x of lower part for Med_Med law | x1 |
| | | | 2 | x2 | Median summary point of x of center part for Med_Med law | x2 |
| | | | 3 | x3 | Median summary point of x of upper part for Med_Med law | x3 |
| | | | 4 | y1 | Median summary point of y of lower part for Med_Med law | y1 |
| | | | 5 | y2 | Median summary point of y of center part for Med_Med law | y2 |
| | | | 6 | y3 | Median summary point of y of upper part for Med_Med law | y3 |
| | | | 7 | Q1 | Specifies median Q1 of Med and Xmin then displays it on screen | Q1 |
| | | | 8 | Med | Specifies median Med of a data then displays it on screen | Med |
| | | | 9 | Q3 | Specifies median Q3 of Xmax and Med then displays it on screen | Q3 |
| | | D TEST | 01 | p | Specified probability (p) then transfers it to screen | p |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STAT VAR | D TEST | 02 | z | Specifies test statistic value (z) then displays it on screen | z |
| | | | 03 | t | Specifies test statistic value (t) then displays it on screen | t |
| | | | 04 | $\chi^2$ | Specifies test statistic value ($\chi^2$) then displays it on screen | $\chi^2$ |
| | | | 05 | F | Specifies test statistic value (F) then displays it on screen | F |
| | | | 06 | df | Specifies degree of freedom df then displays it on screen | df |
| | | | 07 | $\hat{p}$ | Specifies estimated sample proportion then displays it on screen | $\hat{p}$ |
| | | | 08 | $\hat{p}1$ | Specifies estimated sample proportion of population 1 then displays it on screen | $\hat{p}1$ |
| | | | 09 | $\hat{p}2$ | Specifies estimated sample proportion of population 2 then displays it on screen | $\hat{p}2$ |
| | | | 10 | s | Specifies standard line error (s) then displays it on screen | s |
| | | | 11 | n1 | Specifies number of data points for sample 1 (n1) then displays it on screen | n1 |
| | | | 12 | n2 | Specifies number of data points for sample 2 (n2) then displays it on screen | n2 |
| | | | 13 | $\bar{x}1$ | Specifies sample mean ($\bar{x}1$) of x value of sample 1 then displays it on screen | $\bar{x}1$ |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| * | STAT VAR | D TEST | 14 | $\overline{x}2$ | Specifies sample mean ($\overline{x}2$) of x value of sample 2 then displays it on screen | $\overline{x}2$ |
| | | | 15 | sx1 | Specifies sample standard deviation (sx1) of x value of sample 1 then displays it on screen | sx1 |
| | | | 16 | sx2 | Specifies sample standard deviation (sx2) of x value of sample 2 then displays it on screen | sx2 |
| | | | 17 | sxp | Specifies standard deviation (sxp) for pooling then displays it on screen | sxp |
| | | | 18 | lower | Specifies confidence bound lower limit (lower) then displays it on screen | lower |
| | | | 19 | upper | Specifies confidence bound upper limit (upper) then displays it on screen | upper |
| | MATRIX | A NAME | 1 | mat A | Specifies matrix A then displays it on screen | mat A |
| | | | 2 | mat B | Specifies matrix B then displays it on screen | mat B |
| | | | 3 | mat C | Specifies matrix C then displays it on screen | mat C |
| | | | 4 | mat D | Specifies matrix D then displays it on screen | mat D |
| | | | 5 | mat E | Specifies matrix E then displays it on screen | mat E |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATRIX | A NAME | 6 | mat F | Specifies matrix F then displays it on screen | mat F |
| | | | 7 | mat G | Specifies matrix G then displays it on screen | mat G |
| | | | 8 | mat H | Specifies matrix H then displays it on screen | mat H |
| | | | 9 | mat I | Specifies matrix I then displays it on screen | mat I |
| | | | 0 | mat J | Specifies matrix J then displays it on screen | mat J |
| | | B EDIT | 1 | mat A | Specifies edit mode of matrix A | mat A |
| | | | 2 | mat B | Specifies edit mode of matrix B | mat B |
| | | | 3 | mat C | Specifies edit mode of matrix C | mat C |
| | | | 4 | mat D | Specifies edit mode of matrix D | mat D |
| | | | 5 | mat E | Specifies edit mode of matrix E | mat E |
| | | | 6 | mat F | Specifies edit mode of matrix F | mat F |
| | | | 7 | mat G | Specifies edit mode of matrix G | mat G |
| | | | 8 | mat H | Specifies edit mode of matrix H | mat H |
| | | | 9 | mat I | Specifies edit mode of matrix I | mat I |
| | | | 0 | mat J | Specifies edit mode of matrix J | mat J |

| | EL-9650 functions | | | | | |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | Description | Example of use |
| | MATRIX | C OPE | 01 | dim ( | Finds list length and matrix size<br>Defines list length and matrix size | dim (list name) dim (matrix name)<br>(matrix size is returned with list)<br>List length→dim list name,{row,column}<br>→ dim matrix name |
| | | | 02 | fill( | Satisfies list element with specified value | fill (value, matrix name), fill (value, list name) |
| | | | 03 | cumul | Creates cumulative list and cumulative matrix (cumulative list with lines as one list) | cumul list, cumul matrix name,<br>cumul list name |
| | | | 04 | augment( | Augments two lists | augment(C,D)<br>C and D are lists, matrix names or list names |
| | | | 05 | identity | Creates a simple matrix | identity(matrix size) |
| | | | 06 | rnd_mat( | Creates a random matrix | rnd_mat(row, column) |
| | | | 07 | row_swap( | Swaps rows of matrices | row_swap(matrix name,swap row A,swap row B) |
| | | | 08 | row_plus( | Adds rows of matrices<br>(row A + row B →row B) | row_plus(matrix name,add row A,added row B) |
| | | | 09 | row_mult( | Multiplies a row of matrix<br>(multiplied number × row A →row A) | row_mult (multiplied number,matrix name, row number A) |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | MATRIX | C OPE | 10 | row_m.p.( | Multiplies a row of matrix then adds rows of matrices (multiplied number × row A + row B → row B) | row_m.p.(multiplied number,matrix name,row number A,added row B) |
| | | | 11 | mat→list( | Satisfies individual lists by elements from individual columns of a matrix | mat→list(list name 1...,list name n), mat→list(line number,list name), |
| | | | 12 | list→mat( | Satisfies a matrix with line units by elements from individually specified lists | list→mat(list or list name 1,...,matrix name) |
| | | D MATH | 1 | det | Executes calculation of a matrix equation | det matrix |
| | | | 2 | trans | Exchanges row and column (finds transposed matrix) | trans matrix |
| | | | 3 | rowEF | Returns the row-echelon form of a matrix | rowEF matrix |
| | | | 4 | rrowEF | Returns the reduced row-echelon form of a matrix | rrowEF matrix |
| | | E [ ] | 1 | [ | Sets parentheses of a matrix | |
| | | | 2 | ] | Closes parentheses of a matrix | |
| | PRGM | A EXEC | | | Executes program | |
| | | B EDIT | | | Sets edit mode of program | |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | PRGM | C NEW | | | Sets new program create mode | |
| | STAT PLOT | A PLOT1 | | | Specifies statistic graph 1 (PLOT1) | PLOT1 |
| | | B PLOT2 | | | Specifies statistic graph 2 (PLOT2) | PLOT2 |
| | | C PLOT3 | | | Specifies statistic graph 3 (PLOT3) | PLOT3 |
| | | D LIMIT | 1 | SET | Set limit line of statistic graph | SET |
| | | | 2 | LimON | Draws limit line on statistic graph | LimON |
| | | | 3 | LimOFF | Does not draw limit line on statistic graph | LimOFF |
| | | E ON/ OFF | 1 | PlotON | Makes Plot1 - Plot3 valid | Plot ON |
| | | | 2 | PlotOFF | Do not display plot1 - plot3 | Plot OFF |
| | | | | | | |
| | STAT GRAPH * | A HIST | 1 | Hist | Specifies histogram | Hist |
| | | B B.L. | 1 | Broken • | specifies broken line plot using data point "•" | Broken • |
| | | | 2 | Broken + | specifies broken line plot using data point "+" | Broken + |
| | | | 3 | Broken □ | specifies broken line plot using data point "□" | Broken □ |
| | | C N.P. | 1 | Norm•_X | Specifies X coordinate as data value, Y coordinate as inverse conversion value (z) of normal distribution with data point "•" | Norm•_X |

* Select by pressing 2ndF STATPLOT in the STAT GRAPH settings screen of PLOT 1 to 3.

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT GRAPH | C N.P. | 2 | Norm+_X | Specifies X coordinate as data value, Y coordinate as inverse conversion value (z) of normal distribution with data point "+" | Norm+_X |
| | | | 3 | Norm □_X | Specifies X coordinate as data value, Y coordinate as inverse conversion value (z) of normal distribution with data point "□" | Norm □_X |
| | | | 4 | Norm •_Y | Specifies X coordinate as in verse conversion value (z) of normal distribution, Y coordinate as data value and data point as "•" | Norm •_Y |
| | | | 5 | Norm+_Y | Specifies X coordinate as inverse conversion value (z) of normal distribution, Y coordinate as data value and data point as "+" | Norm+_Y |
| | | | 6 | Norm □_Y | Specifies X coordinate as inverse conversion value (z) of normal distribution, Y coordinate as data value and data point as "□" | Norm □_Y |
| | | D N.D. | 1 | NormDis | Specifies normal distribution curve | NormDis |
| | | E BOX | 1 | Box | Specifies box plot. The lines on either side are drawn the length of Q1-Xmin and Q3-Xmax | Box |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT GRAPH | F MBOX | 1 | MBox • | Specifies modified box plot. The lines on either side are (Q3–Q1) $\times$ 1.5 Uses "•" to draw data points (including Xmin and Xmax) of the lines that are on the outside | MBox • |
| | | | 2 | MBox + | Specifies modified box plot. The lines on either side are (Q3–Q1) $\times$ 1.5 Uses "+" to draw data points (including Xmin and Xmax) of the lines that are on the outside | MBox + |
| | | | 3 | MBox □ | Specifies modified box plot. The lines on either side are (Q3–Q1)*1.5 Uses "□" to draw data points (including Xmin and Xmax) of the lines that are on the outside | MBox □ |
| | | G S.D. | 1 | Scattr • | Specifies scatter diagram with "•" as data points | Scattr • |
| | | | 2 | Scattr + | Specifies scatter diagram with "+" as data points | Scattr + |
| | | | 3 | Scattr □ | Specifies scatter diagram with "□" as data points | Scattr □ |
| | | H XYLINE | 1 | xyLine • | Specifies xyLine with "•" as data points | xyLine • |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | STAT GRAPH | H XYLINE | 2 | xyLine + | Specifies xyLine with "+" as data points | xyLine + |
| | | | 3 | xyLine □ | Specifies xyLine with "□" as data points | xyLine □ |
| | | | | | | |
| | OPTION | A CTRST | | | Sets contrast adjustment mode of the display sceen | |
| | | B MEMCHK | | | Sets memory usage check screen | |
| | | C DEL | 1 | List | Sets mode to delete existing lists | List |
| | | | 2 | Matrix | Sets mode to delete existing matrices | Matrix |
| | | | 3 | Graph Eqn | Sets mode to delete existing graphs | Graph Eqn |
| | | | 4 | Solver Eqn | Sets mode to delete existing solvers | Solver Eqn |
| | | | 5 | Program | Sets mode to delete existing programs | Program |
| | | | 6 | Picture | Sets mode to delete existing Pict data | Picture |
| | | | 7 | G_DATA | Sets mode to delete existing graph data | G_DATA |
| | | | 8 | L_DATA | Sets mode to delete existing list data | L_DATA |
| | | | 9 | Slide | Sets mode to delete self-made slide shows | Slide |
| | | | 0 | Entry | Sets mode to delete entered data | Entry |
| | | D LINK | 1 | SEND | Sets to data send mode | SEND |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | OPTION | D LINK | 2 | RECEIVE | Sets to data receive mode | RECEIVE |
| | | E RESET | 1 | default set | Resets the settings to default values | default set |
| | | | 2 | All memory | Resets all memory and set to default condition | All memory |
| | LINK (SEND) | A SELECT | 01 | All | Selects all equations | All |
| | | | 02 | List | Selects only the data stored in list | List |
| | | | 03 | Matrix | Selects only matrices | Matrix |
| | | | 04 | Graph Eqn | Selects only graph function equations | Graph Eqn |
| | | | 05 | Solver Eqn | Selects only Solver data | Solver Eqn |
| | | | 06 | Program | Selects only program data | Program |
| | | | 07 | G_DATA | Selects only graph data | G_DATA |
| | | | 08 | L_DATA | Selects only list data | L_DATA |
| | | | 09 | Picture | Selects only picture data | Picture |
| | | | 10 | Slide | Selects only self-made slide shows | Slide |
| | | | 11 | A ~ Z, $\theta$ | Selects only the data stored in constant memory | A ~ Z, $\theta$ |
| | | B BACKUP | | | Selects all data | |
| | LINK (RECEIVE) | | | | Sets to data receive mode | |
| | SLIDE SHOW | A B–IN | 1 | $Y=X^2$ | Opens the slide show screen of "$Y=X^2$" | $Y=X^2$ |
| | | | 2 | Y=AX+B | Opens the slide show screen of "Y=AX+B" | Y=AX+B |
| | | | 3 | $Y=\sqrt{X}$ | Opens the slide show screen of "$Y=\sqrt{X}$" | $Y=\sqrt{X}$ |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | SLIDE SHOW | A B-IN | 4 | Y=1/X | Opens the slide show screen of “Y=1/X” | Y=1/X |
| | | | 5 | Y=sin X | Opens the slide show screen of “Y=sin X” | Y=sin X |
| | | | 6 | Y=tan X | Opens the slide show screen of “Y=tan X” | Y=tan X |
| | | | 7 | $Y=\cos^{-1}X$ | Opens the slide show screen of “$Y=\cos^{-1}X$” | $Y=\cos^{-1}X$ |
| | | | 8 | Y=ln X | Opens the slide show screen of “Y=lnX” | Y=ln X |
| | | B ORG | | | Opens the self-made slide show screen | |
| | | C NEW | | | Opens the self-made slide show create screen | |
| | | D EDIT | 1 | MOVE | Opens the screen move mode of the self-made slide show screen | MOVE |
| | | | 2 | DEL | Open the delete mode of the self-made slide show screen | DEL |
| | | | 3 | RENAME | Opens the rename mode of the self-made slide show screen | RENAME |
| | | | | | | |
| | SHIFT CHANGE | A SHIFT | 1 | $Y=X^2$ | Opens the SHIFT screen of “$Y=X^2$” | $Y=X^2$ |
| | | | 2 | $Y=\sqrt{X}$ | Opens the SHIFT screen of “$Y=\sqrt{X}$” | $Y=\sqrt{X}$ |
| | | | 3 | Y=1/X | Opens the SHIFT screen of “Y=1/X” | Y=1/X |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | SHIFT CHANGE | A SHIFT | 4 | $Y=e^x$ | Opens the SHIFT screen of "$Y=e^x$" | $Y=e^x$ |
| | | | 5 | Y=lnX | Opens the SHIFT screen of "Y=lnX" | Y=lnX |
| | | | 6 | Y=sinX | Opens the SHIFT screen of "Y=sinX" | Y=sinX |
| | | | 7 | Y=tanX | Opens the SHIFT screen of "Y=tanX" | Y=tanX |
| | | | 8 | $Y=\|X\|$ | Opens the SHIFT screen of "$Y=\|X\|$" | $Y=\|X\|$ |
| | | B CHANGE | 1 | $Y=X^2$ | Opens the CHANGE screen of "$Y = X^2$" | $Y=X^2$ |
| | | | 2 | $Y=\sqrt{X}$ | Opens the CHANGE screen of "$Y=\sqrt{X}$" | $Y=\sqrt{X}$ |
| | | | 3 | $Y=\|X\|$ | Opens the CHANGE screen of "$Y=\|X\|$" | $Y=\|X\|$ |
| | | | 4 | $Y=e^x$ | Opens the CHANGE screen of "$Y=e^x$" | $Y=e^x$ |
| | | | 5 | Y=sin X | Opens the CHANGE screen of "Y=sinX" | Y=sin X |
| | | | 6 | Y=tan X | Opens the CHANGE screen of "Y=tanX" | Y=tan X |
| | TOOL | A NBASE | | | Sets to N-base mode | |
| | | B SYSTEM | 2 | 2 | Sets to mode that solves simultaneous linear equations with two unknown values | |
| | | | 3 | 3 | Sets to mode that solves simultaneous linear equations with three unknown values | |

| | EL-9650 functions | | | | Description | Example of use |
|---|---|---|---|---|---|---|
| | Major-category | Sub-category | Minor-category | Name | | |
| | TOOL | B SYSTEM | 4 | 4 | Sets to mode that solves simultaneous linear equations with four unknown values | |
| | | | 5 | 5 | Sets to mode that solves simultaneous linear equations with five unknown values | |
| | | | 6 | 6 | Sets to mode that solves simultaneous linear equations with six unknown values | |
| | | C POLY | 2 | 2 | Sets to mode that solves quadratic equations | |
| | | | 3 | 3 | Sets to mode that solves cubic equations | |
| | SOLVER (SOLVER) | A METHOD | 1 | Equation | Solves equation directly from the numerical equation | Equation |
| | | | 2 | Newton | Solves equation from graph | Newton |
| | | | 3 | Graphic | Solves equation from graph | Graphic |
| | | B EQTN | | | Recalls equation registered with SOLVER | |
| | | | | | | |
| | | C SAVE | | | Opens the register screen of equation entered with SOLVER | |
| | | | | | | |
| | | D RENAME | | | Opens the mode in which names of equations registered with SOLVER can be renamed | |

SET UP ( 2nd F SET UP )

- A ---------
  - Rad
  - FloatPt
  - 9
  - Rect
  - Decimal (Real)
  - Equation
- B DRG
  - 1 Deg
  - 2 Rad
  - 3 Grad
- C FSE
  - 1 FloatPt
  - 2 Fix
  - 3 Sci
  - 4 Eng
- D TAB
  - 1 1
  - 2 2
  - 3 3
  - 4 4
  - 5 5
  - 6 6
  - 7 7
  - 8 8
  - 9 9
  - 0 0
- E COORD
  - 1 Rect
  - 2 Param
  - 3 Polar
  - 4 Seq
- F ANSWER
  - 1 Decimal (Real)
  - 2 Mixed (Real)
  - 3 Improp (Real)
  - 4 x±yi (complex)
  - 5 r∠θ (complex)
- G EDITOR
  - 1 Equation
  - 2 One line

FORMAT ( 2nd F FORMAT )

- A ---------
  - RectCoord
  - OFF
  - OFF
  - Connect
  - Sequen
- B CURSOR
  - 1 RectCoord
  - 2 PolarCoord
- C EXPRES
  - 1 ON
  - 2 OFF
- D Y'
  - 1 ON
  - 2 OFF
- E STYLE1
  - 1 Connect
  - 2 Dot
- F STYLE2
  - 1 Sequen
  - 2 Simul

* When coordinate system is Rect, param or polar

FORMAT ( 2nd F FORMAT )

| A --------- | B CURSOR | C EXPRES | D Y' | E STYLE1 |
|---|---|---|---|---|
| RectCoord | 1 RectCoord | 1 ON | 1 ON | 1 Connect |
| OFF | 2 PolarCoord | 2 OFF | 2 OFF | 2 Dot |
| OFF | | | | |
| Connect | | | | |
| Sequen | | | | |
| Time | | | | |

| F STYLE2 | G TYPE |
|---|---|
| 1 Sequen | 1 Web |
| 2 Simul | 2 Time |
| | 3 uv |
| | 4 uw |
| | 5 vw |

* When coordinate system is Seq.

MATH ( MATH )

| A CALC | | B NUM | C PROB | D CONV |
|---|---|---|---|---|
| 01 log2 | 11 cot | 1 abs ( | 1 random | 1 →deg |
| 02 $2^x$ | 12 $sec^{-1}$ | 2 round ( | 2 nPr | 2 →dms |
| 03 fmin ( | 13 $csc^{-1}$ | 3 ipart | 3 nCr | 3 xy→r ( |
| 04 fmax ( | 14 $cot^{-1}$ | 4 fpart | 4 ! | 4 xy→θ ( |
| 05 d/dx ( | 15 sinh | 5 int | | 5 rθ→x ( |
| 06 ∫ | 16 cosh | 6 min ( | | 6 rθ→y ( |
| 07 dx | 17 tanh | 7 max ( | | |
| 08 ∑ ( | 18 $sinh^{-1}$ | 8 lcm ( | | |
| 09 sec | 19 $cosh^{-1}$ | 9 gcd ( | | |
| 10 csc | 20 $tanh^{-1}$ | | | |

| E ANGLE | F INEQ | G LOGIC | H COMPLX |
|---|---|---|---|
| 1 ° | 1 = | 1 and | 1 conj ( |
| 2 ′ | 2 ≠ | 2 or | 2 real ( |
| 3 ″ | 3 > | 3 not | 3 image ( |
| 4 $^r$ | 4 ≥ | 4 xor | 4 abs ( |
| 5 $^g$ | 5 < | 5 xnor | 5 arg ( |
| | 6 ≤ | | |

When coordinate system is Rect

CALC ( 2nd F CALC )

A CALC
- 1 Value
- 2 Intsct
- 3 Minimum
- 4 Maximum
- 5 X_Incpt
- 6 Y_Incpt
- 7 Inflec

When coordinate system is Polar, Param or Seq

CALC ( 2nd F CALC )

A CALC
- 1 Value

MATH menu on the NBASE calculation

A NBASE ( MATH on NBASE screen)

A LOGIC
- 1 and
- 2 or
- 3 not
- 4 neg
- 5 xor
- 6 xnor

LIST ( 2nd F LIST )

A OPE
- 1 sortA (
- 2 sortD (
- 3 dim (
- 4 fill(
- 5 seq(
- 6 cumul
- 7 df_list
- 8 augment (
- 9 list→mat (
- 0 mat→list (

B MATH
- 1 min (
- 2 max (
- 3 mean (
- 4 median (
- 5 sum (
- 6 prod (
- 7 stdDv (
- 8 varian (

C L_DATA
- 1 StoLD
- 2 RclLD

STAT ( STAT )

A EDIT

edit list

Press ENTER

B OPE
- 1 sortA (
- 2 sortD (
- 3 SetList
- 4 ClrList

C CALC
- 1 1_Stats
- 2 2_Stats
- 3 ANOVA (

D REG
- 01 Med_Med
- 02 Rg_ax+b
- 03 Rg_a+bx
- 04 Rg_$x^2$
- 05 Rg_$x^3$
- 06 Rg_$x^4$
- 07 Rg_ln
- 08 Rg_log
- 09 Rg_$ab^x$
- 10 Rg_$ae^{bx}$
- 11 Rg_$x^{-1}$
- 12 Rg_$ax^b$
- 13 Rg_logistic
- 14 Rg_sin
- 15 x´
- 16 y´

E TEST
- 01 $\chi^2$test
- 02 Ftest2samp
- 03 Ttest1samp
- 04 Ttest2samp
- 05 TtestLinreg
- 06 Tint1samp
- 07 Tint2samp
- 08 Ztest1samp
- 09 Ztest2samp
- 10 Ztest1prop
- 11 Ztest2prop
- 12 Zint1samp
- 13 Zint2samp
- 14 Zint1prop
- 15 Zint2prop
- 16 InputList
- 17 Input Stats

F DISTRI
- 01 pdfnorm (
- 02 cdfnorm (
- 03 InvNorm (
- 04 pdfT (
- 05 cdfT (
- 06 pdf$\chi^2$(
- 07 cdf$\chi^2$(
- 08 pdfF (
- 09 cdfF (
- 10 pdfbin (
- 11 cdfbin (
- 12 pdfpoi (
- 13 cdfpoi (
- 14 pdfgeo (
- 15 cdfgeo (

**DRAW** (2nd F DRAW)

- **A DRAW**
  - 1 ClrDraw
  - 2 Line (
  - 3 H_Line
  - 4 V_Line
  - 5 T_Line(
  - 6 Draw
  - 7 Shade (
  - 8 DrawInv
  - 9 Circle (
  - 0 Text (
- **B POINT**
  - 1 PntON (
  - 2 PntOFF (
  - 3 PntCHG (
  - 4 PxION (
  - 5 PxIOFF (
  - 6 PxICHG (
  - 7 PxITST (
- **C ON/OFF**
  - 1 DrawON
  - 2 DawOFF
- **D LINE**
  - select line type
  - Press ENTER
- **E G_DATA**
  - 1 StoGD
  - 2 RclGD
- **F PICT**
  - 1 StoPict
  - 2 RclPict
- **G SHADE**
  - 1 SET
  - 2 INITIAL

**ZOOM** (ZOOM)

- **A ZOOM**
  - 1 Auto
  - 2 Box
  - 3 In
  - 4 Out
  - 5 Default
  - 6 Square
  - 7 Dec
  - 8 Int
  - 9 Stat
- **B FACTOR**
  - Set factor of zoom
  - Press ENTER
- **C POWER**
  - 1 $X^2$
  - 2 $X^{-1}$
  - 3 $\sqrt{X}$
- **D EXP**
  - 1 $10^x$
  - 2 $e^x$
  - 3 log x
  - 4 ln x
- **E TRIG**
  - 1 sin x
  - 2 cos x
  - 3 tan x
  - 4 $\sin^{-1}$ x
  - 5 $\cos^{-1}$ x
  - 6 $\tan^{-1}$ x
- **F HYP**
  - 1 sinh x
  - 2 cosh x
  - 3 tanh x
  - 4 $\sinh^{-1}$x
  - 5 $\cosh^{-1}$x
  - 6 $\tanh^{-1}$x
- **G STO**
  - 1 StoWin
- **H RCL**
  - 1 RclWin
  - 2 PreWin

PROGM-COM ( 2nd F PRGM on Program screen )

- A PRGM
  - 1 Print
  - 2 ″
  - 3 Input
  - 4 Wait
  - 5 Rem
  - 6 End
- B BRNCH
  - 1 Label
  - 2 Goto
  - 3 If
  - 4 Gosub
  - 5 Return
- C SCRN
  - 1 ClrT
  - 2 ClrG
  - 3 DispT
  - 4 DispG
- D I/O
  - 1 Get
  - 2 Send
- E COORD
  - 1 Rect
  - 2 Param
  - 3 Polar
  - 4 Web
  - 5 Time
  - 6 uv
  - 7 uw
  - 8 vw
- F FORM
  - 1 RectCursor
  - 2 PolarCursor
  - 3 ExprON
  - 4 ExprOFF
  - 5 Y' ON
  - 6 Y' OFF
  - 7 Connect
  - 8 Dot
  - 9 Sequen
  - 0 Simul
- G S_PLOT
  - 1 Plt1 (
  - 2 Plt2 (
  - 3 Plt3 (
- H COPY
  - 1 StoLine
  - 2 RclLine

VARS ( VARS )

- A EQVARS
  - Graph equation
  - Press ENTER
- B WINDOW
  - Value of window
  - Press ENTER
- C STOWIN
  - Value of stored window
  - Press ENTER
- D L_DATA
  - 1 L_Data 1
  - 2 L_Data 2
  - 3 L_Data 3
  - 4 L_Data 4
  - 5 L_Data 5
  - 6 L_Data 6
  - 7 L_Data 7
  - 8 L_Data 8
  - 9 L_Data 9
  - 0 L_Data 0
- E G_DATA
  - 1 G_Data 1
  - 2 G_Data 2
  - 3 G_Data 3
  - 4 G_Data 4
  - 5 G_Data 5
  - 6 G_Data 6
  - 7 G_Data 7
  - 8 G_Data 8
  - 9 G_Data 9
  - 0 G_Data 0
- F PICTUR
  - 1 Pict1
  - 2 Pict2
  - 3 Pict3
  - 4 Pict4
  - 5 Pict5
  - 6 Pict6
  - 7 Pict7
  - 8 Pict8
  - 9 Pict9
  - 0 Pict0
- G TABLE
  - 1 TBLStrt
  - 2 TBLStep
  - 3 TBLList
- H STAT
  - Statistics
  - Press ENTER

**EQ VAR** ( VARS A )

- A XY
  - 1 Y1
  - 2 Y2
  - 3 Y3
  - 4 Y4
  - 5 Y5
  - 6 Y6
  - 7 Y7
  - 8 Y8
  - 9 Y9
  - 0 Y0
- B XYT
  - 01 X1T
  - 02 Y1T
  - 03 X2T
  - 04 Y2T
  - 05 X3T
  - 06 Y3T
  - 07 X4T
  - 08 Y4T
  - 09 X5T
  - 10 Y5T
  - 11 X6T
  - 12 Y6T
- C Rθ
  - 1 R1
  - 2 R2
  - 3 R3
  - 4 R4
  - 5 R5
  - 6 R6

**WIN VAR** ( VARS B )

- A XY
  - 1 Xmin
  - 2 Xmax
  - 3 Xscl
  - 4 Ymin
  - 5 Ymax
  - 6 Yscl
  - 7 X_Fact
  - 8 Y_Fact
- B T
  - 1 Tmin
  - 2 Tmax
  - 3 Tstep
- C θ
  - 1 θmin
  - 2 θmax
  - 3 θstep
- D SEQ
  - 1 nMin
  - 2 nMax
  - 3 u (nMin)
  - 4 v (nMin)
  - 5 w (nMin)
  - 6 PlotStart
  - 7 PlotStep

**STOWIN VAR** ( VARS C )

- A STOXY
  - 1 Zm_Xmin
  - 2 Zm_Xmax
  - 3 Zm_Xscl
  - 4 Zm_Ymin
  - 5 Zm_Ymax
  - 6 Zm_Yscl
- B STOT
  - 1 Zm_Tmin
  - 2 Zm_Tmax
  - 3 Zm_Tstp
- C STOθ
  - 1 Zm_θmin
  - 2 Zm_θmax
  - 3 Zm_θstp
- D STOSEQ
  - 1 Zm_nMin
  - 2 Zm_nMax
  - 3 Zm_u (nMin)
  - 4 Zm_v (nMin)
  - 5 Zm_w (nMin)
  - 6 Zm_PltStart
  - 7 Zm_PltStp

**STAT VAR** ( VARS H )

| A XY | B REGEQN | C POINTS | D TEST |
|---|---|---|---|
| 01 n | 1 RegEqn | 1 x1 | 01 p |
| 02 $\bar{x}$ | 2 a | 2 x2 | 02 z |
| 03 sx | 3 b | 3 x3 | 03 t |
| 04 $\sigma$x | 4 c | 4 y1 | 04 $\chi^2$ |
| 05 xmin | 5 d | 5 y2 | 05 F |
| 06 xmax | 6 e | 6 y3 | 06 df |
| 07 $\sum x$ | 7 r | 7 Q1 | 07 $\hat{p}$ |
| 08 $\sum x^2$ | 8 $r^2$ | 8 Med | 08 $\hat{p}1$ |
| 09 $\sum xy$ | 9 $R^2$ | 9 Q3 | 09 $\hat{p}2$ |
| 10 $\bar{y}$ | 0 resid | | 10 s |
| 11 sy | | | 11 n1 |
| 12 $\sigma$y | | | 12 n2 |
| 13 ymin | | | 13 $\bar{x}1$ |
| 14 ymax | | | 14 $\bar{x}2$ |
| 15 $\sum y$ | | | 15 sx1 |
| 16 $\sum y^2$ | | | 16 sx2 |
| | | | 17 sxp |
| | | | 18 lower |
| | | | 19 upper |

**MATRIX** ( MATRIX )

| A NAME | B EDIT | C OPE | D MATH | E [ ] |
|---|---|---|---|---|
| 1 mat A | 1 mat A | 01 dim ( | 1 det | 1 [ |
| 2 mat B | 2 mat B | 02 fill ( | 2 trans | 2 ] |
| 3 mat C | 3 mat C | 03 cumul | 3 rowEF | |
| 4 mat D | 4 mat D | 04 augment ( | 4 rrowEF | |
| 5 mat E | 5 mat E | 05 identity | | |
| 6 mat F | 6 mat F | 06 rnd_mat ( | | |
| 7 mat G | 7 mat G | 07 row_swap ( | | |
| 8 mat H | 8 mat H | 08 row_plus ( | | |
| 9 mat I | 9 mat I | 09 row_mult ( | | |
| 0 mat J | 0 mat J | 10 row_m.p. ( | | |
| | | 11 mat→list ( | | |
| | | 12 list→mat ( | | |

**PRGM** ( 2nd F PRGM )

| A EXEC | B EDIT | C NEW |
|---|---|---|
| 01 | 01 | Create new program |
| 02 | 02 | |
| 03 | 03 | |
| 04 | 04 | Press ENTER |
| 05 | 05 | |
| 06 | 06 | |

**STAT PLOT** ( 2nd F STATPLOT )

- A PLOT1
  - Stat plot1
  - Press ENTER
- B PLOT2
  - Stat plot2
  - Press ENTER
- C PLOT3
  - Stat plot3
  - Press ENTER
- D LIMIT
  - 1 SET
  - 2 LimON
  - 3 LimOFF
- E ON/OFF
  - 1 PlotON
  - 2 PlotOFF

**OPTION** ( 2nd F OPTION )

- A CTRST
- B MEMCHK
  - Remain
    12345bytes
  - Press ENTER
    to detail
- C DEL
  - 1 List
  - 2 Matrix
  - 3 Graph Eqn
  - 4 Solver Eqn
  - 5 Program
  - 6 Picture
  - 7 G_Data
  - 8 L_Data
  - 9 Slide
  - 0 Entry
- D LINK
  - 1 SEND
  - 2 RECEIVE
- E RESET
  - 1 default set
  - 2 All memory

**STAT GRAPH** ( 2nd F STATPLOT on PLOT 1-3 screen )

- A HIST
  - 1 Hist
- B B.L.
  - 1 Broken•
  - 2 Broken+
  - 3 Broken□
- C N.P.
  - 1 Norm•_X
  - 2 Norm+_X
  - 3 Norm□_X
  - 4 Norm•_Y
  - 5 Norm+_Y
  - 6 Norm□_Y
- D N.D.
  - 1 NormDis
- E BOX
  - 1 Box
- F MBOX
  - 1 MBox•
  - 2 MBox+
  - 3 MBox□
- G S.D.
  - 1 Scattr•
  - 2 Scattr+
  - 3 Scattr□
- H XYLINE
  - 1 xyLine•
  - 2 xyLine+
  - 3 xyLine□

**SLIDE** ( SLIDE SHOW )

- A B–IN
  - 1 $Y=X^2$
  - 2 Y=AX+B
  - 3 $Y=\sqrt{X}$
  - 4 Y=1/X
  - 5 Y=sinX
  - 6 Y=tanX
  - 7 $Y=\cos^{-1}X$
  - 8 Y=lnX
- B ORG
  - 0 screen
- C NEW
  - Press ENTER
- D EDIT
  - 1 MOVE
  - 2 DEL
  - 3 RENAME

**SHIFT / CHANGE** ( 2nd F SHIFT/CHANGE )

- A SHIFT
  - 1 $Y=X^2$
  - 2 $Y=\sqrt{X}$
  - 3 Y=1/X
  - 4 $Y=e^x$
  - 5 Y=lnX
  - 6 Y=sinX
  - 7 Y=tanX
  - 8 Y=|X|
- B CHANGE
  - 1 $Y=X^2$
  - 2 $Y=\sqrt{X}$
  - 3 Y=|X|
  - 4 $Y=e^x$
  - 5 Y=sinX
  - 6 Y=tanX

**SOLVER** ( 2nd F SOLVER on SOLVER screen )

- A METHOD
  - 1 Equation
  - 2 Newton
  - 3 Graphic
- B EQTN
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
  - 0
- C SAVE
  - Press ENTER
- C RENAME
  - 1
  - 2
  - 3
  - 4
  - 5
  - 6
  - 7
  - 8
  - 9
  - 0

**TOOL** ( 2nd F TOOL )

- A NBASE
  - Calculate
    - Hexadecimal
    - Decimal
    - Octal
    - Binary
  - Press ENTER
- B SYSTEM
  - 2 2
  - 3 3
  - 4 4
  - 5 5
  - 6 6
  - Select number
- C POLY
  - 2 2
  - 3 3
  - Select degree

**Y=** ( Y= )

| RECT MODE | PARAM MODE | POLAR MODE | SEQ MODE |
|---|---|---|---|
| Y1= | X1T= | R1= | u (n)= |
| Y2= | Y1T= | R2= | u (nMin)= |
| Y3= | X2T= | R3= | v (n)= |
| Y4= | Y2T= | R4= | v (nMin)= |
| Y5= | X3T= | R5= | w (n)= |
| Y6= | Y3T= | R6= | w (nMin)= |
| Y7= | X4T= | | |
| Y8= | Y4T= | | |
| Y9= | X5T= | | |
| Y0= | Y5T= | | |
| | X6T= | | |
| | Y6T= | | |

**FINANCE** ( 2nd F FINANCE )

| A SOLVER | B CALC | C PERIOD | D VARS |
|---|---|---|---|
| TVM Solver | 01 slv_pmt | 1 PmtEnd | 1 N |
| | 02 slv_I% | 2 PmtBegin | 2 I% |
| | 03 slv_PV | | 3 PV |
| Press ENTER | 04 slv_N | | 4 PMT |
| | 05 slv_FV | | 5 FV |
| | 06 Npv ( | | 6 P/Y |
| | 07 Irr ( | | 7 C/Y |
| | 08 Bal ( | | |
| | 09 ∑Prn ( | | |
| | 10 ∑Int ( | | |
| | 11 →Apr ( | | |
| | 12 →Eff ( | | |
| | 13 days ( | | |

**SEND** ( 2nd F OPTION D 1 )

| A SELECT | B BACKUP |
|---|---|
| 01 All | back up |
| 02 List | |
| 03 Matrix | Press ENTER |
| 04 Graph Eqn | |
| 05 Solver Eqn | |
| 06 Program | |
| 07 G_Data | |
| 08 L_Data | |
| 09 Picture | |
| 10 Slide | |
| 11 A ~ Z, θ | |

# Index



## A



## B

## B(cont.)



## C



## C(cont.)

# C(cont.)



# C(cont.)



# D

## D(cont.)



## D(cont.)



## E

## E(cont.)



## F



## F(cont.)



## G



## H

## H(cont.)



## I



## I(cont.)



## K



## L

## L(cont.)



## M



## M(cont.)

## M(cont.)



## N



## O



## O(cont.)



## P

# P(cont.)



# P(cont.)

## Q



## R



## R(cont.)



## S

# S(cont.)



# S(cont.)

## S(cont.)



## S(cont.)



## T

## T(cont.)



## T(cont.)



## U



## V

## V(cont.)



## W



## X



## X(cont.)



## Y



## Z

## Z(cont.)