fx-3650P
fx-3950P
User's Guide
Guía del usuario
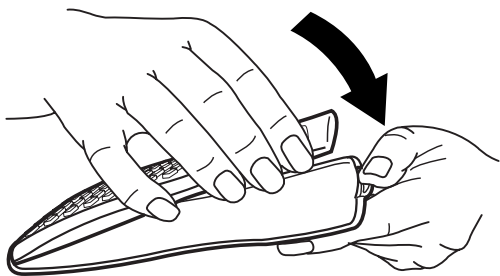
Safety Precautions

Be sure to read the following safety precautions before using this calculator.
Keep this manual handy for later reference.

⚠ **Caution**

This symbol is used to indicate information that can result in personal injury or material damage if ignored.

Batteries
• After removing the battery from the calculator, put it in a safe place where it will not get into the hands of small children and accidentally swallowed.
• Keep batteries out of the reach of small children. If accidentally swallowed, consult with a physician immediately.
• Never charge batteries, try to take batteries apart, or allow batteries to become shorted. Never expose batteries to direct heat or dispose of them by incineration.
• Misuse of batteries can cause them to leak and damage nearby items, and can create the risk of fire and personal injury.
  • Always make sure that the battery's positive ⊕ and negative ⊖ ends are facing correctly when you load it into the calculator.
  • Remove the battery if you do not plan to use the calculator for a long time (fx-3950P).
  • Use only the type of battery specified for this calculator in this manual.

Disposing of the Calculator
• Never dispose of the calculator by burning it. Doing so can cause certain components to suddenly burst, creating the risk of fire and personal injury.

• The displays and illustrations (such as key markings) shown in this User's Guide are for illustrative purposes only, and may differ somewhat from the actual items they represent.
• The contents of this manual are subject to change without notice.

E-2

Handling Precautions

- **Be sure to press the ON key before using the calculator for the first time.**
- **Even if the calculator is operating normally, replace the battery at least once every three years.**
  A dead battery can leak, causing damage to and malfunction of the calculator. Never leave a dead battery in the calculator.
- **The battery that comes with this unit discharges slightly during shipment and storage. Because of this, it may require replacement sooner than the normal expected battery life.**
- **Low battery power can cause memory contents to become corrupted or lost completely. Always keep written records of all important data.**
- **Avoid use and storage in areas subjected to temperature extremes.**
  Very low temperatures can cause slow display response, total failure of the display, and shortening of battery life. Also avoid leaving the calculator in direct sunlight, near a window, near a heater or anywhere else it might be exposed to very high temperatures. Heat can cause discoloration or deformation of the calculator's case, and damage to internal circuitry.
- **Avoid use and storage in areas subjected to large amounts of humidity and dust.**
  Take care never to leave the calculator where it might be splashed by water or exposed to large amounts of humidity or dust. Such conditions can damage internal circuitry.
- **Never drop the calculator or otherwise subject it to strong impact.**

- **Never twist or bend the calculator.**
  Avoid carrying the calculator in the pocket of your trousers or other tight-fitting clothing where it might be subjected to twisting or bending.

- **Never try to take the calculator apart.**

- **Never press the keys of the calculator with a ballpoint pen or other pointed object.**

- **Use a soft, dry cloth to clean the exterior of the calculator.**
  If the calculator becomes very dirty, wipe it off with a cloth moistened in a weak solution of water and a mild neutral household detergent. Wring out all excess moisture before wiping the calculator. Never use thinner, benzene or other volatile agents to clean the calculator. Doing so can remove printed markings and can damage the case.

Contents

Before getting started...

■Key Markings

Many of the calculator's keys are used to perform more than one function.
The functions marked on the keyboard are color coded to help you find the
one you need quickly and easily.
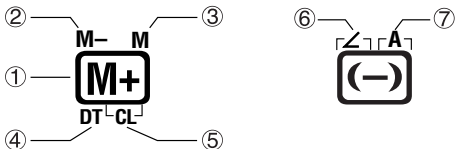
	Function	**Color**	**Key Operation**
①	M+		$\boxed{\text{M+}}$
②	M–	Orange	$\boxed{\text{SHIFT}}$ $\boxed{\text{M+}}$ Press $\boxed{\text{SHIFT}}$ and then the key to perform the marked function.
③	M	Red	$\boxed{\text{ALPHA}}$ $\boxed{\text{M+}}$ Press $\boxed{\text{ALPHA}}$ and then the key to perform the marked function.
④	DT	Blue	In the SD and REG Modes: $\boxed{\text{M+}}$
⑤	CL	Orange In blue brackets	In the SD and REG Modes: $\boxed{\text{SHIFT}}$ $\boxed{\text{M+}}$ Press $\boxed{\text{SHIFT}}$ and then the key to perform the marked function.
⑥	∠	Orange In purple brackets	In the CMPLX Mode: $\boxed{\text{SHIFT}}$ $\boxed{(-)}$ Press $\boxed{\text{SHIFT}}$ and then the key to perform the marked function.
⑦	A	Red In green brackets	$\boxed{\text{ALPHA}}$ $\boxed{(-)}$ Press $\boxed{\text{ALPHA}}$ and then the key to specify variable A. $\boxed{(-)}$ In the BASE Mode, press the key without pressing $\boxed{\text{ALPHA}}$.

■Modes

Before starting a calculation, you must first enter the correct mode as indicated in the table below.

To perform this type of operation:	Perform this key operation:	To enter this mode:
Basic arithmetic calculations	`MODE` `1`	COMP
Complex number calculations	`MODE` `2`	CMPLX
Standard deviation	`MODE` `MODE` `1`	SD
Regression calculations	`MODE` `MODE` `2`	REG
Base-n calculations	`MODE` `MODE` `3`	BASE
Program editing	`MODE` `MODE` `MODE` `1`	PRGM
Program execution	`MODE` `MODE` `MODE` `2`	RUN
Program deletion	`MODE` `MODE` `MODE` `3`	PCL

• Pressing the `MODE` key more than three times displays additional setup screens. Setup screens are described where they are actually used to change the calculator setup.
• In this manual, the name of the mode you need to enter in order to perform the calculations being described is indicated in the main title of each section.

Example:

Complex Number Calculations CMPLX

Note!

• To return the calculation mode and setup to the initial defaults shown below, press `SHIFT` `CLR` `2` (Mode) `EXE`.

Calculation Mode:	COMP
Angle Unit:	Deg
Exponential Display Format:	Norm 1
Complex Number Display Format:	$a+bi$
Fraction Display Format:	ab/c

• Mode indicators appear in the upper part of the display, except for the BASE indicators, which appear in the exponent part of the display.

- You cannot make changes to the angle unit or other display format (Disp) settings while the calculator is in the BASE Mode.
- The COMP, CMPLX, SD, and REG modes can be used in combination with the angle unit settings.
- Be sure to check the current calculation mode (SD, REG, COMP, CMPLX) and angle unit setting (Deg, Rad, Gra) before beginning a calculation.

■Input Capacity

- The memory area used for calculation input can hold 79 "steps." One step is taken up each time you press a number key or arithmetic operator key (➕, ➖, ✖, ➗). A SHIFT or ALPHA key operation does not take up a step, so inputting SHIFT √⎺, for example, takes up only one step.
- You can input up to 79 steps for a single calculation. Whenever you input the 73rd step of any calculation, the cursor changes from "_" to "■" to let you know memory is running low. If you need to input more than 79 steps, you should divide your calculation into two or more parts.
- Pressing the Ans key recalls the last result obtained, which you can use in a subsequent calculation. See "Answer Memory" for more information about using the Ans key.

■Making Corrections During Input

- Use ◀ and ▶ to move the cursor to the location you want.
- Press DEL to delete the number or function at the current cursor position.
- Press SHIFT INS to change to an insert cursor ⌶. Inputting something while the insert cursor is on the display inserts the input at the insert cursor position.
- Pressing SHIFT INS, or EXE returns to the normal cursor from the insert cursor.

■Replay Function

- Every time you perform a calculation, the replay function stores the calculation formula and its result in replay memory. Pressing the ▲ key displays the formula and result of the calculation you last performed. Pressing ▲ again back steps sequentially (new-to-old) through past calculations.

E-9

- Pressing the ◀ or ▶ key while a replay memory calculation is on the display changes to the editing screen.
- Pressing the ◀ or ▶ key immediately after you finish a calculation displays the editing screen for that calculation.
- Pressing **AC** does not clear replay memory, so you can recall the last calculation even after you press **AC**.
- Replay memory capacity is 128 bytes for storage of both expressions and results.
- Replay memory is cleared by any of the following actions.
  When you press the **ON** key
  When you initialize modes and settings by pressing **SHIFT** **CLR** **2** (or **3**) **EXE**
  When you change from one calculation mode to another
  When you turn off the calculator.

■Error Locator

- Pressing ▶ or ◀ after an error occurs displays the calculation with the cursor positioned at the location where the error occurred.

■Exponential Display Formats

This calculator can display up to 10 digits. Larger values are automatically displayed using exponential notation. In the case of decimal values, you can select between two formats that determine at what point exponential notation is used.

- To change the exponential display format, press the **MODE** key a number of times until you reach the exponential display format setup screen shown below.

```
Fix Sci Norm
 1    2    3
```

- Press **3**. On the format selection screen that appears, press **1** to select Norm 1 or **2** for Norm 2.

• Norm 1

With Norm 1, exponential notation is automatically used for integer values with more than 10 digits and decimal values with more than two decimal places.

• Norm 2

With Norm 2, exponential notation is automatically used for integer values with more than 10 digits and decimal values with more than nine decimal places.

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

■ Initializing the Calculator (Reset Operation)

• Performing the key operation below initializes the calculation mode and setup, and clears replay memory, variables, and all programs.

$\boxed{\text{SHIFT}}$ $\boxed{\text{CLR}}$ $\boxed{3}$ (All) $\boxed{\text{EXE}}$

Basic Calculations $\qquad$ COMP

■ Arithmetic Calculations

Use the $\boxed{\text{MODE}}$ key to enter the COMP Mode when you want to perform basic calculations.

COMP .... $\boxed{\text{MODE}}$ $\boxed{1}$

• **Example 1:** $3 \times (5 \times 10^{-9}) = \boldsymbol{1.5 \times 10^{-8}}$ $\qquad$ 3 $\boxed{\times}$ 5 $\boxed{\text{EXP}}$ $\boxed{(-)}$ 9 $\boxed{\text{EXE}}$

• **Example 2:** $5 \times (9+7) = \boldsymbol{80}$ $\qquad$ 5 $\boxed{\times}$ $\boxed{(}$ 9 $\boxed{+}$ 7 $\boxed{)}$ $\boxed{\text{EXE}}$

• You can skip all $\boxed{)}$ operations before $\boxed{\text{EXE}}$.

■Fraction Operations

• Fraction Calculations

- Values are displayed in decimal format automatically whenever the total number of digits of a fractional value (integer + numerator + denominator + separator marks) exceeds 10.

- **Example 1:** $\frac{2}{3} + \frac{1}{5} = \mathbf{\frac{13}{15}}$ 2 $\boxed{a\%}$ 3 $\boxed{+}$ 1 $\boxed{a\%}$ 5 $\boxed{\text{EXE}}$ $\boxed{13\lrcorner15.}$

- **Example 2:** $3\frac{1}{4} + 1\frac{2}{3} = \mathbf{4\frac{11}{12}}$ 3 $\boxed{a\%}$ 1 $\boxed{a\%}$ 4 $\boxed{+}$
  1 $\boxed{a\%}$ 2 $\boxed{a\%}$ 3 $\boxed{\text{EXE}}$ $\boxed{4\lrcorner11\lrcorner12.}$

- **Example 3:** $\frac{2}{4} = \mathbf{\frac{1}{2}}$ 2 $\boxed{a\%}$ 4 $\boxed{\text{EXE}}$

- **Example 4:** $\frac{1}{2} + 1.6 = \mathbf{2.1}$ 1 $\boxed{a\%}$ 2 $\boxed{+}$ 1.6 $\boxed{\text{EXE}}$

- Results of calculations that mix fraction and decimal values are always decimal.

• Decimal ↔ Fraction Conversion

- Use the operation shown below to convert calculation results between decimal values and fraction values.
- Note that conversion can take as long as two seconds to perform.

- **Example 1:** $2.75 = 2\frac{3}{4}$ (Decimal → Fraction)

  2.75 $\boxed{\text{EXE}}$ $\boxed{2.75}$

  $\boxed{a\%}$ $\boxed{2\lrcorner3\lrcorner4.}$

  $= \frac{11}{4}$ $\boxed{\text{SHIFT}}$ $\boxed{d/c}$ $\boxed{11\lrcorner4.}$

- **Example 2:** $\frac{1}{2} \leftrightarrow 0.5$ (Fraction ↔ Decimal)

  1 $\boxed{a\%}$ 2 $\boxed{\text{EXE}}$ $\boxed{1\lrcorner2.}$

  $\boxed{a\%}$ $\boxed{0.5}$

  $\boxed{a\%}$ $\boxed{1\lrcorner2.}$

• Mixed Fraction ⟷ Improper Fraction Conversion

• **Example:** $1\frac{2}{3} \Leftrightarrow \frac{5}{3}$

1 $\boxed{a\%}$ 2 $\boxed{a\%}$ 3 $\boxed{\text{EXE}}$ | $1\lrcorner2\lrcorner3.$ |

$\boxed{\text{SHIFT}}$ $\boxed{\text{d/c}}$ | $5\lrcorner3.$ |

$\boxed{\text{SHIFT}}$ $\boxed{\text{d/c}}$ | $1\lrcorner2\lrcorner3.$ |

• You can use the display setup (Disp) screen to specify the display format when a fraction calculation result is greater than one.
• To change the fraction display format, press the $\boxed{\text{MODE}}$ key a number of times until you reach the setup screen shown below.

```
Disp
1
```

• Display the selection screen.

$\boxed{1}$ (or $\boxed{1}$ $\boxed{\blacktriangleright}$ in the CMPLX Mode)

• Press the number key ($\boxed{1}$ or $\boxed{2}$) that corresponds to the setting you want to use.

$\boxed{1}(a^b/_c)$: Mixed fraction
$\boxed{2}(d/c)$: Improper fraction

• An error occurs if you try to input a mixed fraction while the d/c display format is selected.

■ Percentage Calculations

• **Example 1:** To calculate 12% of 1500 *(180)* 1500 $\boxed{\times}$ 12 $\boxed{\text{SHIFT}}$ $\boxed{\%}$

• **Example 2:** To calculate what percentage of 880 is 660 *(75%)*

660 $\boxed{\div}$ 880 $\boxed{\text{SHIFT}}$ $\boxed{\%}$

• **Example 3:** To add 15% onto 2500 *(2875)* 2500 $\boxed{\times}$ 15 $\boxed{\text{SHIFT}}$ $\boxed{\%}$ $\boxed{+}$

• **Example 4:** To discount 3500 by 25% *(2625)* 3500 $\boxed{\times}$ 25 $\boxed{\text{SHIFT}}$ $\boxed{\%}$ $\boxed{-}$

• **Example 5:** To discount the sum of 168, 98, and 734 by 20% *(800)*

168 $\boxed{+}$ 98 $\boxed{+}$ 734 $\boxed{\text{EXE}}$ $\boxed{\text{Ans}}$ $\boxed{\text{SHIFT}}$ $\boxed{\text{STO}}$ $\boxed{A}$

$\boxed{\text{ALPHA}}$ $\boxed{A}$ $\boxed{\times}$ 20 $\boxed{\text{SHIFT}}$ $\boxed{\%}$ $\boxed{-}$
*

E-13

* As shown here, if you want to use the current Answer Memory value in a mark up or discount calculation, you need to assign the Answer Memory value into a variable and then use the variable in the mark up/ discount calculation. This is because the calculation performed when ⌐%⌐ is pressed stores a result to Answer Memory before the ⌐−⌐ key is pressed.

• **Example 6:** If 300 grams are added to a test sample originally weighing 500 grams, what is the percentage increase in weight? *(160%)*

300 ⊞ 500 [SHIFT] [%]

• **Example 7:** What is the percentage change when a value is increased from 40 to 46? How about to 48? *(15%, 20%)*

46 ⊟ 40 [SHIFT] [%]

◀ ◀ ◀ ◀ ◀ ◀ 8 [EXE]

■ Degrees, Minutes, Seconds Calculations

• You can perform sexagesimal calculations using degrees (hours), minutes, and seconds, and convert between sexagesimal and decimal values.

• **Example 1:** To convert the decimal value 2.258 to a sexagesimal value and then back to a decimal value

2.258 [EXE]	2.258
[SHIFT] [∴⊸]	2°15°28.8
[∴⊸]	2.258

• **Example 2:** To perform the following calculation: 12°34'56" + 65°43'21"

12 [∴⊸] 34 [∴⊸] 56 [∴⊸]

⊞ 65 [∴⊸] 43 [∴⊸] 21 [∴⊸] [EXE] | 78°18°17 |

■ FIX, SCI, RND

• To change the settings for the number of decimal places, the number of significant digits, or the exponential display format, press the [MODE] key a number of times until you reach the setup screen shown below.

```
Fix Sci Norm
 1   2   3
```

E-14

- Press the number key ($\boxed{1}$, $\boxed{2}$, or $\boxed{3}$) that corresponds to the setup item you want to change.

  $\boxed{1}$ (Fix): Number of decimal places
  $\boxed{2}$ (Sci): Number of significant digits
  $\boxed{3}$ (Norm): Exponential display format

- **Example 1:** $200 \div 7 \times 14 =$ 200 $\boxed{\div}$ 7 $\boxed{\times}$ 14 $\boxed{\text{EXE}}$

	400.

(Specifies three decimal places.) $\boxed{\text{MODE}}$ ····· $\boxed{1}$(Fix) $\boxed{3}$

	FIX
	400.000

(Internal calculation continues using 12 digits.)   200 $\boxed{\div}$ 7 $\boxed{\text{EXE}}$

	28.571

$\boxed{\times}$ 14 $\boxed{\text{EXE}}$

	400.000

The following performs the same calculation using the specified number of decimal places.

200 $\boxed{\div}$ 7 $\boxed{\text{EXE}}$

	28.571

(Internal rounding) $\boxed{\text{SHIFT}}$ $\boxed{\text{Rnd}}$

	28.571

$\boxed{\times}$ 14 $\boxed{\text{EXE}}$

	399.994

- Press $\boxed{\text{MODE}}$ ····· $\boxed{3}$(Norm) $\boxed{1}$ to clear the Fix specification.

- **Example 2:** $1 \div 3$, displaying result with two significant digits (Sci 2)

$\boxed{\text{MODE}}$ ····· $\boxed{2}$(Sci) $\boxed{2}$ 1 $\boxed{\div}$ 3 $\boxed{\text{EXE}}$

	SCI
	3.3×10^{-01}

- Press $\boxed{\text{MODE}}$ ····· $\boxed{3}$(Norm) $\boxed{1}$ to clear the Sci specification.

Memory Calculations $\underline{\text{COMP}}$

Use the $\boxed{\text{MODE}}$ key to enter the COMP Mode when you want to perform a calculation using memory.

COMP .... $\boxed{\text{MODE}}$ $\boxed{1}$

■Answer Memory

- Whenever you press $\boxed{\text{EXE}}$ after inputting values or an expression, the calculated result automatically updates Answer Memory contents by storing the result.
- In addition to $\boxed{\text{EXE}}$, Answer Memory contents are also updated with result whenever you press $\boxed{\text{SHIFT}}$ $\boxed{\%}$, $\boxed{\text{M+}}$, $\boxed{\text{SHIFT}}$ $\boxed{\text{M–}}$, or $\boxed{\text{SHIFT}}$ $\boxed{\text{STO}}$ followed by a letter (A through D, or M, X, or Y).
- You can recall Answer Memory contents by pressing $\boxed{\text{Ans}}$.
- Answer Memory can store up to 12 digits for the mantissa and two digits for the exponent.
- Answer Memory contents are not updated if the operation performed by any of the above key operations results in an error.

■Consecutive Calculations

- You can use the calculation result that is currently on the display (and also stored in Answer Memory) as the first value of your next calculation. Note that pressing an operator key while a result is displayed causes the displayed value to change to Ans, indicating it is the value that is currently stored in Answer Memory.
- The result of a calculation can also be used with a subsequent Type A function (x^2, x^3, x^{-1}, $x!$, DRG►), +, –, $^\wedge(x^y)$, $\sqrt[x]{}$, ×, ÷, nPr and nCr.

■Independent Memory

- Values can be input directly into memory, added to memory, or subtracted from memory. Independent memory is convenient for calculating cumulative totals.
- Independent memory uses the same memory area as variable M.
- To clear independent memory (M), input $\boxed{0}$ $\boxed{\text{SHIFT}}$ $\boxed{\text{STO}}$ $\boxed{\text{M}}$.

- **Example:**

$23 + 9 = \boldsymbol{32}$	23 $\boxed{+}$ 9 $\boxed{\text{SHIFT}}$ $\boxed{\text{STO}}$ $\boxed{\text{M}}$
$53 - 6 = \boldsymbol{47}$	53 $\boxed{-}$ 6 $\boxed{\text{M+}}$
$-)\ 45 \times 2 = \boldsymbol{90}$	45 $\boxed{\times}$ 2 $\boxed{\text{SHIFT}}$ $\boxed{\text{M–}}$
(Total) $\boldsymbol{-11}$	$\boxed{\text{RCL}}$ $\boxed{\text{M}}$

■Variables

- There are seven variables (A through D, M, X and Y), which can be used to store data, constants, results, and other values.
- Use the following operation to delete data assigned to a particular variable: $\boxed{0}$ $\boxed{\text{SHIFT}}$ $\boxed{\text{STO}}$ $\boxed{A}$. This operation deletes the data assigned to variable A.
- Perform the following key operation when you want to clear the values assigned to all of the variables.

  $\boxed{\text{SHIFT}}$ $\boxed{\text{CLR}}$ $\boxed{1}$ (Mcl) $\boxed{\text{EXE}}$

- **Example:** $\underline{193.2} \div 23 = \textbf{8.4}$ 193.2 $\boxed{\text{SHIFT}}$ $\boxed{\text{STO}}$ $\boxed{A}$ $\boxed{\div}$ 23 $\boxed{\text{EXE}}$

  $\underline{193.2} \div 28 = \textbf{6.9}$ $\boxed{\text{ALPHA}}$ $\boxed{A}$ $\boxed{\div}$ 28 $\boxed{\text{EXE}}$

Complex Number Calculations   ⟨CMPLX⟩

Use the $\boxed{\text{MODE}}$ key to enter the CMPLX Mode when you want to perform calculations that include complex numbers.

CMPLX .... $\boxed{\text{MODE}}$ $\boxed{2}$

- The current angle unit setting (Deg, Rad, Gra) affects CMPLX Mode calculations.
- Note that you can use variables A, B, C, and M only in the CMPLX Mode. You cannot use variables D, X, and Y.
- The indicator "R↔I" in the upper right corner of a calculation result display indicates a complex number result. Press $\boxed{\text{SHIFT}}$ $\boxed{\text{Re↔Im}}$ to toggle the display between the real part and imaginary part of the result.
- You can use the replay function in the CMPLX Mode. Since complex numbers are stored in replay memory in the CMPLX Mode, however, more memory than normal is used up.

- **Example:** $(2+3i)+(4+5i) = \textbf{6}+\textbf{8}\textbf{\textit{i}}$

  (Real part 6)   2 $\boxed{+}$ 3 $\boxed{i}$ $\boxed{+}$ 4 $\boxed{+}$ 5 $\boxed{i}$ $\boxed{\text{EXE}}$

  (Imaginary part $8i$) $\boxed{\text{SHIFT}}$ $\boxed{\text{Re↔Im}}$

■Absolute Value and Argument Calculation

Supposing the imaginary number expressed by the rectangular form $z = a + bi$ is represented as a point in the Gaussian plane, you can determine the absolute value (r) and argument (θ) of the complex number. The polar form is $r\angle\theta$.

- **Example 1:** To determine the absolute value (r) and argument (θ) of $3 + 4i$ (Angle unit: Deg)   ($r = \textbf{5}$, $\theta = \textbf{53.13010235}°$)

Imaginary axis

Real axis
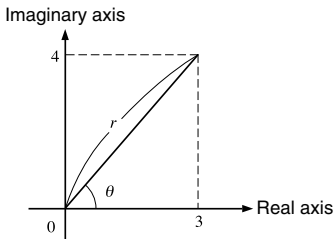
($r = \textbf{5}$)   [SHIFT] [Abs] [(] 3 [+] 4 [i] [)] [EXE]

($\theta = \textbf{53.13010235}°$)   [SHIFT] [arg] [(] 3 [+] 4 [i] [)] [EXE]

- The complex number can also be input using the polar form $r\angle\theta$.

- **Example 2:** $\sqrt{2} \angle 45 = \textbf{1} + \textbf{\textit{i}}$
  (Angle unit: Deg)   [√] 2 [SHIFT] [∠] 45 [EXE]

                                     [SHIFT] [Re↔Im]

■Rectangular Form ↔ Polar Form Display

You can use the operation described below to convert a rectangular form complex number to its polar form, and a polar form complex number to its rectangular form. Press [SHIFT] [Re↔Im] to toggle the display between the absolute value (r) and argument (θ).

- **Example:** $1 + i ↔ 1.414213562 \angle 45$

  (Angle unit: Deg)   1 [+] [i] [SHIFT] [▸r∠θ] [EXE] [SHIFT] [Re↔Im]

                   [√] 2 [SHIFT] [∠] 45 [SHIFT] [▸a+b*i*] [EXE] [SHIFT] [Re↔Im]

- You select rectangular form (*a+bi*) or polar form (*r*∠θ) for display of complex number calculation results.

  [MODE] ····· 1 (Disp)

  1 (*a+bi*): Rectangular form

  2 (*r*∠θ): Polar form (indicated by "*r*∠θ" on the display)

■Conjugate of a Complex Number

For any complex number *z* where *z* = *a+bi*, its conjugate ($\bar{z}$) is $\bar{z}$ = *a−bi*.

- **Example:** To determine the conjugate of the complex number 1.23 + 2.34*i* (Result: ***1.23 – 2.34i***)

  [SHIFT] [Conjg] (1 · 23 + 2 · 34 *i*) [EXE]

  [SHIFT] [Re↔Im]

Base-*n* Calculations   BASE

Use the [MODE] key to enter the BASE Mode when you want to perform calculations using Base-*n* values.

BASE .... [MODE] [MODE] 3

- In addition to decimal values, calculations can be performed using binary, octal and hexadecimal values.
- You can specify the default number system to be applied to all input and displayed values, and the number system for individual values as you input them.
- You cannot use scientific functions in binary, octal, decimal, and hexadecimal calculations. You cannot input values that include decimal part and an exponent.
- If you input a value that includes a decimal part, the unit automatically cuts off the decimal part.
- Negative binary, octal, and hexadecimal values are produced by taking the two's complement.
- You can use the following logical operators between values in Base-*n* calculations: and (logical product), or (logical sum), xor (exclusive or), xnor (exclusive nor), Not (bitwise complement), and Neg (negation).

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

Binary	$1000000000 \leqq x \leqq 1111111111$
	$0 \leqq x \leqq 0111111111$
Octal	$4000000000 \leqq x \leqq 7777777777$
	$0 \leqq x \leqq 3777777777$
Decimal	$-2147483648 \leqq x \leqq 2147483647$
Hexadecimal	$80000000 \leqq x \leqq$ FFFFFFFF
	$0 \leqq x \leqq$ 7FFFFFFF

- **Example 1:** To perform the following calculation and produce a binary result:

$10111_2 + 11010_2 = \textbf{\textit{110001}}_{\textbf{\textit{2}}}$

Binary mode:	$\boxed{\text{AC}}$ $\boxed{\text{BIN}}$	0. ^{b}
	10111 $\boxed{+}$ 11010 $\boxed{\text{EXE}}$	110001. ^{b}

- **Example 2:** To convert the value 22_{10} to its binary, octal, and hexadecimal equivalents. $\textbf{\textit{(10110}}_{\textbf{\textit{2}}}\textbf{\textit{, 26}}_{\textbf{\textit{8}}}\textbf{\textit{, 16}}_{\textbf{\textit{16}}}\textbf{\textit{)}}$

Binary mode:	$\boxed{\text{AC}}$ $\boxed{\text{BIN}}$	0. ^{b}
	$\boxed{\text{LOGIC}}$ $\boxed{\text{LOGIC}}$ $\boxed{\text{LOGIC}}$ $\boxed{1}$(d) 22 $\boxed{\text{EXE}}$	10110. ^{b}
Octal mode:	$\boxed{\text{OCT}}$	26. ^{o}
Hexadecimal mode:	$\boxed{\text{HEX}}$	16. ^{H}

- **Example 3:** To convert the value 513_{10} to its binary equivalent.

Binary mode:	$\boxed{\text{AC}}$ $\boxed{\text{BIN}}$	0. ^{b}
	$\boxed{\text{LOGIC}}$ $\boxed{\text{LOGIC}}$ $\boxed{\text{LOGIC}}$ $\boxed{1}$(d) 513 $\boxed{\text{EXE}}$	Math ERROR $_b$

- You may not be able to convert a value from a number system whose calculation range is greater than the calculation range of the resulting number system.
- The message "Math ERROR" indicates that the result has too many digits (overflow).

- **Example 4:** To perform the following calculation and produce an octal result:

$7654_8 \div 12_{10} = \textbf{\textit{516}}_{\textbf{\textit{8}}}$

Octal mode: [AC] [OCT]   `0. °`

                        [LOGIC] [LOGIC] [LOGIC] [4] (o) 7654 [÷]
                        [LOGIC] [LOGIC] [LOGIC] [1] (d) 12 [EXE]   `516. °`

- **Example 5:** To perform the following calculation and produce a hexadecimal and a decimal result:

120_{16} or $1101_2 = \textbf{\textit{12d}}_{\textbf{\textit{16}}} = \textbf{\textit{301}}_{\textbf{\textit{10}}}$

Hexadecimal mode: [AC] [HEX]   `0. H`

                                 120 [LOGIC] [2] (or)
                       [LOGIC] [LOGIC] [LOGIC] [3] (b) 1101 [EXE]   `12d. H`

Decimal mode: [DEC]   `301. d`

Scientific Function Calculations COMP

Use the [MODE] key to enter the COMP Mode when you want to perform basic arithmetic calculations.

COMP .... [MODE] [1]

- Certain types of calculations may take a long time to complete.
- Wait for the result to appear on the display before starting the next calculation.
- $\pi = 3.14159265359$

■Trigonometric/Inverse Trigonometric Functions

- To change the default angle unit (degrees, radians, grads), press the [MODE] key a number of times until you reach the angle unit setup screen shown below.

$$\boxed{\begin{array}{ccc} \text{Deg} & \text{Rad} & \text{Gra} \\ 1 & 2 & 3 \end{array}}$$

- Press the number key ($\boxed{1}$, $\boxed{2}$, or $\boxed{3}$) that corresponds to the angle unit you want to use.

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

- **Example 1:** sin 63°52′41″ = **0.897859012**

  $\boxed{\text{MODE}}$ ····· $\boxed{1}$(Deg)

  $\boxed{\sin}$ 63 $\boxed{\cdots}$ 52 $\boxed{\cdots}$ 41 $\boxed{\cdots}$ $\boxed{\text{EXE}}$

- **Example 2:** cos $\left(\dfrac{\pi}{3}\text{ rad}\right)$= **0.5**

  $\boxed{\text{MODE}}$ ····· $\boxed{2}$(Rad)

  $\boxed{\cos}$ $\boxed{(}$ $\boxed{\text{SHIFT}}$ $\boxed{\pi}$ $\boxed{\div}$ 3 $\boxed{)}$ $\boxed{\text{EXE}}$

- **Example 3:** $\cos^{-1}\dfrac{\sqrt{2}}{2}$ = **0.25** π (rad) $\left(=\dfrac{\pi}{4}\text{ (rad)}\right)$

  $\boxed{\text{MODE}}$ ····· $\boxed{2}$ (Rad)

  $\boxed{\text{SHIFT}}$ $\boxed{\cos^{-1}}$ $\boxed{(}$ $\boxed{\sqrt{\ }}$ 2 $\boxed{\div}$ 2 $\boxed{)}$ $\boxed{\text{EXE}}$ $\boxed{\text{Ans}}$ $\boxed{\div}$ $\boxed{\text{SHIFT}}$ $\boxed{\pi}$ $\boxed{\text{EXE}}$

- **Example 4:** $\tan^{-1}$ 0.741 = **36.53844577** °

  $\boxed{\text{MODE}}$ ····· $\boxed{1}$(Deg)

  $\boxed{\text{SHIFT}}$ $\boxed{\tan^{-1}}$ 0.741 $\boxed{\text{EXE}}$

■Hyperbolic/Inverse Hyperbolic Functions

- **Example 1:** sinh 3.6 = **18.28545536**

  $\boxed{\text{hyp}}$ $\boxed{\sin}$ 3.6 $\boxed{\text{EXE}}$

- **Example 2:** $\sinh^{-1}$ 30 = **4.094622224**

  $\boxed{\text{hyp}}$ $\boxed{\text{SHIFT}}$ $\boxed{\sin^{-1}}$ 30 $\boxed{\text{EXE}}$

■Common and Natural Logarithms/Antilogarithms

- **Example 1:** log 1.23 = **0.089905111**

  $\boxed{\log}$ 1.23 $\boxed{\text{EXE}}$

- **Example 2:** ln 90 (= $\log_e$ 90) = **4.49980967**

  $\boxed{\ln}$ 90 $\boxed{\text{EXE}}$

  ln e = **1**

  $\boxed{\ln}$ $\boxed{\text{ALPHA}}$ $\boxed{e}$ $\boxed{\text{EXE}}$

- **Example 3:** e^{10} = **22026.46579**

  $\boxed{\text{SHIFT}}$ $\boxed{e^x}$ 10 $\boxed{\text{EXE}}$

- **Example 4:** $10^{1.5}$ = **31.6227766**

  $\boxed{\text{SHIFT}}$ $\boxed{10^x}$ 1.5 $\boxed{\text{EXE}}$

- **Example 5:** $(-2)^4$ = **16**

  $\boxed{(}$ $\boxed{(-)}$ 2 $\boxed{)}$ $\boxed{\wedge}$ 4 $\boxed{\text{EXE}}$

- Negative values included in a calculation must be enclosed in parentheses. For details, see "Order of Operations" on page 47 for more information.

E-22

■ Square Roots, Cube Roots, Roots, Squares, Cubes, Reciprocals, Factorials, Random Numbers, π, and Permutation/Combination

- **Example 1:** $\sqrt{2} + \sqrt{3} \times \sqrt{5} = $ **5.287196909**   ✓ 2 ➕ ✓ 3 ✖ ✓ 5 EXE

- **Example 2:** $\sqrt[3]{5} + \sqrt[3]{-27} = $ **–1.290024053**   SHIFT ∛ 5 ➕ SHIFT ∛ (−) 27 EXE

- **Example 3:** $\sqrt[7]{123}$ ($= 123^{(\frac{1}{7})}$) = **1.988647795**   7 SHIFT ∜ 123 EXE

- **Example 4:** $123 + 30^2 = $ **1023**   123 ➕ 30 $\boxed{x^2}$ EXE

- **Example 5:** $12^3 = $ **1728**   12 $\boxed{x^3}$ EXE

- **Example 6:** $\dfrac{1}{\dfrac{1}{3} - \dfrac{1}{4}} = $ **12**   (3 $\boxed{x^{-1}}$ ➖ 4 $\boxed{x^{-1}}$) $\boxed{x^{-1}}$ EXE

- **Example 7:** $8! = $ **40320**   8 SHIFT $\boxed{x!}$ EXE

- **Example 8:** To generate a random number between 0.000 and 0.999

  SHIFT Ran# EXE | 0.664

  (The above value is a sample only. Results differ each time.)

- **Example 9:** $3\pi = $ **9.424777961**   3 SHIFT $\boxed{\pi}$ EXE

- **Example 10:** To determine how many different 4-digit values can be produced using the numbers 1 through 7

  - Numbers cannot be duplicated within the same 4-digit value (1234 is allowed, but 1123 is not).   **(840)**

    7 SHIFT $\boxed{nPr}$ 4 EXE

- **Example 11:** To determine how many different 4-member groups can be organized in a group of 10 individuals   **(210)**

    10 SHIFT $\boxed{nCr}$ 4 EXE

■Angle Unit Conversion

• Press $\boxed{\text{SHIFT}}$ $\boxed{\text{DRG▶}}$ to display the following menu.

```
D   R   G
1   2   3
```

• Pressing $\boxed{1}$, $\boxed{2}$, or $\boxed{3}$ converts the displayed value to the corresponding angle unit.

• **Example:** To convert 4.25 radians to degrees

$\boxed{\text{MODE}}$ ····· $\boxed{1}$(Deg)

4.25 $\boxed{\text{SHIFT}}$ $\boxed{\text{DRG▶}}$ $\boxed{2}$(R) $\boxed{\text{EXE}}$

```
      4.25r
243.5070629
```

■Coordinate Conversion (Pol (x, y), Rec (r, θ))
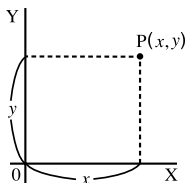
• **Rectangular Coordinates**   • **Polar Coordinates**
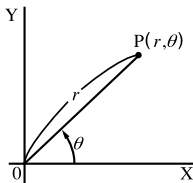
• Calculation results are automatically assigned to variables X and Y.

• **Example 1:** To convert polar coordinates ($r = 2$, $\theta = 60°$) to rectangular coordinates (x, y) (Angle unit: Deg)

$x = \mathit{1}$ $\boxed{\text{SHIFT}}$ $\boxed{\text{Rec(}}$ 2 $\boxed{,}$ 60 $\boxed{)}$ $\boxed{\text{EXE}}$

$y = \mathit{1.732050808}$ $\boxed{\text{RCL}}$ $\boxed{\text{Y}}$

• Press $\boxed{\text{RCL}}$ $\boxed{\text{X}}$ to display the value of x, or $\boxed{\text{RCL}}$ $\boxed{\text{Y}}$ to display the value of y.

- **Example 2:** To convert rectangular coordinates $(1, \sqrt{3})$ to polar coordinates (r, θ) (Angle unit: Rad)

  $r = \mathbf{2}$ $\boxed{\text{SHIFT}}\ \boxed{\text{Pol(}}\ \boxed{1}\ \boxed{\text{,}}\ \boxed{\sqrt{}}\ \boxed{3}\ \boxed{\text{)}}\ \boxed{\text{EXE}}$

  $\theta = \mathbf{1.047197551}$ $\boxed{\text{RCL}}\ \boxed{\text{Y}}$

- Press $\boxed{\text{RCL}}\ \boxed{\text{X}}$ to display the value of r, or $\boxed{\text{RCL}}\ \boxed{\text{Y}}$ to display the value of θ.

■ Engineering Notation Calculations

- **Example 1:** To convert 56,088 meters to kilometers

  $\rightarrow \mathbf{56.088} \times 10^3$ 56088 $\boxed{\text{EXE}}\ \boxed{\text{ENG}}$
  (km)

- **Example 2:** To convert 0.08125 grams to milligrams

  $\rightarrow \mathbf{81.25} \times 10^{-3}$ 0.08125 $\boxed{\text{EXE}}\ \boxed{\text{ENG}}$
  (mg)

Statistical Calculations ⊂SD⊃ ⊂REG⊃

Standard Deviation ⊂SD⊃

Use the $\boxed{\text{MODE}}$ key to enter the SD Mode when you want to perform statistical calculations using standard deviation.

SD .... $\boxed{\text{MODE}}\ \boxed{\text{MODE}}\ \boxed{1}$

- Always start data input with $\boxed{\text{SHIFT}}\ \boxed{\text{CLR}}\ \boxed{1}$ (Scl) $\boxed{\text{EXE}}$ to clear statistical memory.
- Input data using the key sequence shown below.
  <x-data> $\boxed{\text{DT}}$
- Input data is used to calculate values for n, Σx, Σx^2, $\bar{x}$, σ_n and σ_{n-1}, which you can recall using the key operations noted nearby.

To recall this type of value:	Perform this key operation:
Σx^2	$\boxed{\text{SHIFT}}\ \boxed{\text{S-SUM}}\ \boxed{1}$
Σx	$\boxed{\text{SHIFT}}\ \boxed{\text{S-SUM}}\ \boxed{2}$
n	$\boxed{\text{SHIFT}}\ \boxed{\text{S-SUM}}\ \boxed{3}$
$\bar{x}$	$\boxed{\text{SHIFT}}\ \boxed{\text{S-VAR}}\ \boxed{1}$
σ_n	$\boxed{\text{SHIFT}}\ \boxed{\text{S-VAR}}\ \boxed{2}$
σ_{n-1}	$\boxed{\text{SHIFT}}\ \boxed{\text{S-VAR}}\ \boxed{3}$

- **Example:** To calculate σ_{n-1}, σ_n, $\bar{x}$, n, Σx, and Σx^2 for the following data : 55, 54, 51, 55, 53, 53, 54, 52

In the SD Mode:
`SHIFT` `CLR` `1` (Scl) `EXE` (Stat clear)   55 `DT`

$n= \overset{\text{SD}}{}$
1.

Each time you press `DT` to register your input, the number of data input up to that point is indicated on the display (n value).

54 `DT` 51 `DT` 55 `DT`
53 `DT` `DT` 54 `DT` 52 `DT`

Sample Standard Deviation (σ_{n-1}) = **1.407885953**	`SHIFT` `S-VAR` `3` `EXE`
Population Standard Deviation (σ_n) = **1.316956719**	`SHIFT` `S-VAR` `2` `EXE`
Arithmetic Mean ($\bar{x}$) = **53.375**	`SHIFT` `S-VAR` `1` `EXE`
Number of Data (n) = **8**	`SHIFT` `S-SUM` `3` `EXE`
Sum of Values (Σx) = **427**	`SHIFT` `S-SUM` `2` `EXE`
Sum of Squares of Values (Σx^2) = **22805**	`SHIFT` `S-SUM` `1` `EXE`

- After inputting data, you can perform the key operations that calculate statistical results (standard deviation, mean, etc.) in any order. You do not need to follow the order shown above.

Data Input Precautions

- To input the same data twice: <x-data> `DT` `DT`
- To input multiple entries of the same data by specifying the "frequency": <x-data> `SHIFT` `;` <frequency> `DT`
  Example: To input the data 110 ten times   110 `SHIFT` `;` 10 `DT`
- While inputting data or after inputting data is complete, you can use the `▲` and `▼` keys to scroll through data you have input. If you input multiple entries of the same data using `SHIFT` `;` to specify the data frequency (number of data items) as described above, scrolling through data shows both the data item and a separate screen for the data frequency (Freq).
- You can then edit the displayed data, if you want. Input the new value and then press the `EXE` key to replace the old value with the new one. This also means that if you want to perform some other operation (calculation, recall of statistical calculation results, etc.), you should always press the `AC` key first to exit data display.
- Pressing the `DT` key instead of `EXE` after changing a value on the display registers the value you input as a new data item, and leaves the old value as it is.

E-26

- You can delete a data value displayed using ▲ and ▼ by pressing SHIFT CL. Deleting a data value causes all values following it to be shifted up.
- Data values you register are normally stored in calculator memory. The message "Data Full" appears and you will not be able to input any more data if there is no memory left for data storage. If this happens, press the EXE key to display the screen shown below.

$$\text{Ed i tOFF ESC}$$
$$1 \qquad 2$$

Press 2 to exit data input without registering the value you just input. Press 1 if you want to register the value you just input, without saving it in memory. If you do this, however, you will not be able to display or edit any of the data you have input.
- For information about the number of data items that can be stored in memory, see "Statistical Data Memory and Program Memory" on page 44.
- To delete data you have just input, press SHIFT CL.
- After inputting statistical data in the SD Mode or REG Mode, you will be unable to display or edit individual data items any longer after perform either the following operations.
  Changing to another mode
  Changing the regression type (Lin, Log, Exp, Pwr, Inv, Quad)

• Arithmetic Mean

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

• Standard Deviation

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

$$\left[\begin{array}{l}\text{All the data of a finite}\\ \text{population is used to}\\ \text{calculate the standard}\\ \text{deviation for the population.}\end{array}\right]$$

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

$$\left[\begin{array}{l}\text{Sample data for a}\\ \text{population is used to}\\ \text{estimate the standard}\\ \text{deviation for the population.}\end{array}\right]$$

Regression Calculations

Use the MODE key to enter the REG Mode when you want to perform statistical calculations using regression.

REG .... MODE MODE 2

- Entering the REG Mode displays screens like the ones shown below.

$$
\boxed{\begin{matrix} \text{Lin} & \text{Log} & \text{Exp} & \cdot \\ 1 & 2 & 3 & \end{matrix}} \quad \overset{\blacktriangleright}{\underset{\blacktriangleleft}{\rightleftarrows}} \quad \boxed{\begin{matrix} \cdot\text{Pwr} & \text{Inv} & \text{Quad} \\ 1 & 2 & 3 \end{matrix}}
$$
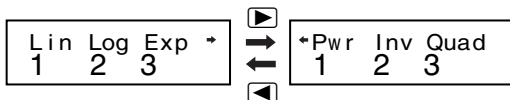
- Press the number key (1, 2, or 3) that corresponds to the type of regression you want to use.

  - 1 (Lin): Linear regression
  - 2 (Log): Logarithmic regression
  - 3 (Exp): Exponential regression
  - ▶ 1 (Pwr): Power regression
  - ▶ 2 (Inv): Inverse regression
  - ▶ 3 (Quad): Quadratic regression

- Always start data input with SHIFT CLR 1 (Scl) EXE to clear statistical memory.
- Input data using the key sequence shown below.
  <x-data> , <y-data> DT
- The values produced by a regression calculation depend on the values input, and results can be recalled using the key operations shown in the table below.

To recall this type of value:	Perform this key operation:
Σx^2	SHIFT S-SUM 1
Σx	SHIFT S-SUM 2
n	SHIFT S-SUM 3
Σy^2	SHIFT S-SUM ▶ 1
Σy	SHIFT S-SUM ▶ 2
Σxy	SHIFT S-SUM ▶ 3
$\bar{x}$	SHIFT S-VAR 1
$x\sigma_n$	SHIFT S-VAR 2
$x\sigma_{n-1}$	SHIFT S-VAR 3
$\bar{y}$	SHIFT S-VAR ▶ 1

E-28

To recall this type of value:	Perform this key operation:
$y\sigma_n$	SHIFT S-VAR ▶ 2
$y\sigma_{n-1}$	SHIFT S-VAR ▶ 3
Regression coefficient A	SHIFT S-VAR ▶ ▶ 1
Regression coefficient B	SHIFT S-VAR ▶ ▶ 2
Regression calculation other than quadratic regression	
Correlation coefficient r	SHIFT S-VAR ▶ ▶ 3
$\hat{x}$	SHIFT S-VAR ▶ ▶ ▶ 1
$\hat{y}$	SHIFT S-VAR ▶ ▶ ▶ 2

- The following table shows the key operations you should use to recall results in the case of quadratic regression.

To recall this type of value:	Perform this key operation:
Σx^3	SHIFT S-SUM ▶ ▶ 1
$\Sigma x^2 y$	SHIFT S-SUM ▶ ▶ 2
Σx^4	SHIFT S-SUM ▶ ▶ 3
Regression coefficient C	SHIFT S-VAR ▶ ▶ 3
$\hat{x}_1$	SHIFT S-VAR ▶ ▶ ▶ 1
$\hat{x}_2$	SHIFT S-VAR ▶ ▶ ▶ 2
$\hat{y}$	SHIFT S-VAR ▶ ▶ ▶ 3

- The values in the above tables can be used inside of expressions the same way you use variables.

• Linear Regression

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

- **Example:** Atmospheric Pressure vs. Temperature

Temperature	Atmospheric Pressure
10°C	1003 hPa
15°C	1005 hPa
20°C	1010 hPa
25°C	1011 hPa
30°C	1014 hPa

Perform linear regression to determine the regression formula terms and correlation coefficient for the data nearby. Next, use the regression formula to estimate atmospheric pressure at 18°C and temperature at 1000 hPa. Finally, calculate the coefficient of determination (r^2) and

sample covariance $\left(\dfrac{\Sigma xy - n \cdot \bar{x} \cdot \bar{y}}{n - 1}\right)$.

In the REG Mode:

1 (Lin)
[SHIFT] [CLR] 1 (Scl) [EXE] (Stat clear)

10 [•] 1003 [DT]

```
          REG
n=
          1.
```

Each time you press [DT] to register your input, the number of data input up to that point is indicated on the display (*n* value).

15 [•] 1005 [DT]
20 [•] 1010 [DT] 25 [•] 1011 [DT]
30 [•] 1014 [DT]

Regression Coefficient A = **997.4**	[SHIFT] [S-VAR] [▶] [▶] 1 [EXE]
Regression Coefficient B = **0.56**	[SHIFT] [S-VAR] [▶] [▶] 2 [EXE]
Correlation Coefficient *r* = **0.982607368**	[SHIFT] [S-VAR] [▶] [▶] 3 [EXE]
Atmospheric Pressure at 18°C = **1007.48**	18 [SHIFT] [S-VAR] [▶] [▶] [▶] 2 [EXE]
Temperature at 1000 hPa = **4.642857143**	1000 [SHIFT] [S-VAR] [▶] [▶] [▶] 1 [EXE]
Coefficient of Determination = **0.965517241**	[SHIFT] [S-VAR] [▶] [▶] 3 [x^2] [EXE]
Sample Covariance = **35**	([SHIFT] [S-SUM] [▶] 3 [−]
	[SHIFT] [S-SUM] 3 [×] [SHIFT] [S-VAR] 1 [×]
	[SHIFT] [S-VAR] [▶] 1) [÷]
	([SHIFT] [S-SUM] 3 [−] 1) [EXE]

• Logarithmic, Exponential, Power, and Inverse Regression

• Use the same key operations as linear regression to recall results for these types of regression.
• The following shows the regression formulas for each type of regression.

Logarithmic Regression	$y = A + B \cdot \ln x$
Exponential Regression	$y = A \cdot e^{B \cdot x}$ ($\ln y = \ln A + Bx$)
Power Regression	$y = A \cdot x^B$ ($\ln y = \ln A + B\ln x$)
Inverse Regression	$y = A + B \cdot {}^1/x$

• Quadratic Regression

• The regression formula for quadratic regression is: $y = A + Bx + Cx^2$.

• **Example:**

xi	yi
29	1.6
50	23.5
74	38.0
103	46.4
118	48.0

Perform quadratic regression to determine the regression formula terms for the data nearby. Next, use the regression formula to estimate the values for $\hat{y}$ (estimated value of y) for $xi = 16$ and $\hat{x}$ (estimated value of x) for $yi = 20$.

In the REG Mode:

▶ 3 (Quad)
SHIFT CLR 1 (Scl) EXE (Stat clear)

$$29 \cdot 1.6 \; \text{DT} \; 50 \cdot 23.5 \; \text{DT}$$
$$74 \cdot 38.0 \; \text{DT} \; 103 \cdot 46.4 \; \text{DT}$$
$$118 \cdot 48.0 \; \text{DT}$$

Regression Coefficient A = **–35.59856934**   SHIFT S-VAR ▶ ▶ 1 EXE

Regression Coefficient B = **1.495939413**   SHIFT S-VAR ▶ ▶ 2 EXE

Regression Coefficient C = **–6.71629667 × 10⁻³**   SHIFT S-VAR ▶ ▶ 3 EXE

$\hat{y}$ when xi is 16 = **–13.38291067**   16 SHIFT S-VAR ▶ ▶ ▶ 3 EXE

$\hat{x}_1$ when yi is 20 = **47.14556728**   20 SHIFT S-VAR ▶ ▶ ▶ 1 EXE

$\hat{x}_2$ when yi is 20 = **175.5872105**   20 SHIFT S-VAR ▶ ▶ ▶ 2 EXE

• After inputting data, you can perform the key operations that calcutate statistical results (regression coefficients, $\hat{y}$, $\hat{x}_1$, etc.) in any order. You do not need to follow the order shown above.

Data Input Precautions

• To input the same data twice: <x-data> ⋅ <y-data> DT DT
• To input multiple entries of the same data by specifying the "frequency": <x-data> ⋅ <y-data> SHIFT ; <frequency> DT
  Example: To input the data X = 20, Y = 30 five times
         20 ⋅ 30 SHIFT ; 5 DT

• Precautions when editing data input for standard deviation also apply for regression calculations.

① **Linear Regression** $y = A + Bx$

- **Regression coefficient A**

$$A = \frac{\Sigma y - B \cdot \Sigma x}{n}$$

- **Regression coefficient B**

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

- **Correlation coefficient r**

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

② **Logarithmic Regression** $y = A + B \cdot \ln x$

- **Regression coefficient A**

$$A = \frac{\Sigma y - B \cdot \Sigma \ln x}{n}$$

- **Regression coefficient B**

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

- **Correlation coefficient r**

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

③ **Exponential Regression** $y = A \cdot e^{B \cdot x} (\ln y = \ln A + Bx)$

- **Regression coefficient A**

$$A = \exp\left(\frac{\Sigma \ln y - B \cdot \Sigma x}{n}\right)$$

- **Regression coefficient B**

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

- **Correlation coefficient r**

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

④ **Power Regression** $y = A \cdot x^B (\ln y = \ln A + B \ln x)$

- **Regression coefficient A**

$$A = \exp\left(\frac{\Sigma \ln y - B \cdot \Sigma \ln x}{n}\right)$$

- **Regression coefficient B**

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

- **Correlation coefficient r**

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

⑤ **Inverse Regression** $y = A + B \cdot {}^1/x$

• **Regression coefficient A** • **Regression coefficient B**

$$A = \frac{\Sigma y - B \cdot \Sigma x^{-1}}{n}$$

$$B = \frac{Sxy}{Sxx}$$

• **Correlation coefficient *r***

$$r = \frac{Sxy}{\sqrt{Sxx \cdot Syy}}$$

$$Sxx = \Sigma(x^{-1})^2 - \frac{(\Sigma x^{-1})^2}{n}, \; Syy = \Sigma y^2 - \frac{(\Sigma y)^2}{n}$$

$$Sxy = \Sigma(x^{-1})y - \frac{\Sigma x^{-1} \cdot \Sigma y}{n}$$

⑥ **Quadratic Regression** $y = A + Bx + Cx^2$

• **Regression coefficient A**

$$A = \frac{\Sigma y}{n} - B\left(\frac{\Sigma x}{n}\right) - C\left(\frac{\Sigma x^2}{n}\right)$$

• **Regression coefficient B**

$$B = (Sxy \cdot Sx^2x^2 - Sx^2y \cdot Sxx^2) \div \{Sxx \cdot Sx^2x^2 - (Sxx^2)^2\}$$

• **Regression coefficient C**

$$C = Sx^2y \cdot Sxx - Sxy \cdot Sxx^2$$

$$Sxx = \Sigma x^2 - \frac{(\Sigma x)^2}{n}, \; Sxy = \Sigma xy - \frac{(\Sigma x \cdot \Sigma y)}{n}$$

$$Sxx^2 = \Sigma x^3 - \frac{(\Sigma x \cdot \Sigma x^2)}{n}, \; Sx^2x^2 = \Sigma x^4 - \frac{(\Sigma x^2)^2}{n}$$

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

Differential Calculations $\quad$ <u>COMP</u>

The procedure described below obtains the derivative of a function.

Use the MODE key to enter the COMP Mode when you want to perform a calculation involving differentials.

COMP .... MODE 1

- Three inputs are required for the differential expression: the function of variable x, the point (a) at which the differential coefficient is calculated, and the change in x (Δx).

$$\text{SHIFT } \boxed{d/dx} \text{ expression } \boxed{,} \; a \; \boxed{,} \; \Delta x \; \boxed{)}$$

- **Example:** To determine the derivative at point $x = 2$ for the function $y = 3x^2 - 5x + 2$, when the increase or decrease in x is $\Delta x = 2 \times 10^{-4}$ (Result: **7**)

SHIFT $\boxed{d/dx}$ 3 ALPHA $\boxed{X}$ $\boxed{x^2}$ $\boxed{-}$ 5 ALPHA $\boxed{X}$ $\boxed{+}$ 2 $\boxed{,}$ 2 $\boxed{,}$ 2 EXP $\boxed{(-)}$ 4 $\boxed{)}$ EXE

- You can omit input of Δx, if you want. The calculator automatically substitutes an appropriate value for Δx if you do not input one.
- Discontinuous points and extreme changes in the value of x can cause inaccurate results and errors.

Integration Calculations $\quad$ <u>COMP</u>

The procedure described below obtains the definite integral of a function.

Use the MODE key to enter the COMP Mode when you want to perform integration calculations.

COMP .... MODE 1

- The following four inputs are required for integration calculations: a function with the variable x; a and b, which define the integration range of the definite integral; and n, which is the number of partitions (equivalent to N = 2^n) for integration using Simpson's rule.

$$\boxed{\int dx} \text{ expression } \boxed{,} \; a \; \boxed{,} \; b \; \boxed{,} \; n \; \boxed{)}$$

- **Example:** $\int_1^5 (2x^2 + 3x + 8) \; dx = \textbf{\textit{150.6666667}}$ (Number of partitions $n = 6$)

$\boxed{\int dx}$ 2 ALPHA $\boxed{X}$ $\boxed{x^2}$ $\boxed{+}$ 3 ALPHA $\boxed{X}$ $\boxed{+}$ 8 $\boxed{,}$ 1 $\boxed{,}$ 5 $\boxed{,}$ 6 $\boxed{)}$ EXE

E-34

Note!

- You can specify an integer in the range of 1 to 9 as the number of partitions, or you can skip input of the number of partitions entirely, if you want.
- Internal integration calculations may take considerable time to complete.
- Display contents are cleared while an integration calculation is being performed internally.
- The conditions described below can cause reduced calculation precision or slower calculation speed.

Condition	Countermeasure
Minute shifts in the integration interval, which causes large change in the integration value	Divide the integration interval, dividing sections that fluctuate widely into smaller intervals.
Periodic functions, or positive and negative integration values depending on the interval	Separate positive and negative parts, and add each together.

Programming a Calculation PRGM PCL RUN

- This section describes how to store a calculation program for instant recall whenever you need it.
- The program storage area has about 360 bytes, which can be divided among up to four different programs named P1, P2, P3, and P4.
- To perform program calculation operations, press MODE MODE MODE, which displays the screen shown below. Next, press the number key that corresponds to the mode you want to select.

```
PRGM RUN PCL
  1   2   3
```

1 (PRGM) .... Edit Prog Mode for inputting and editing programs.
2 (RUN) .... Mode for running programs.
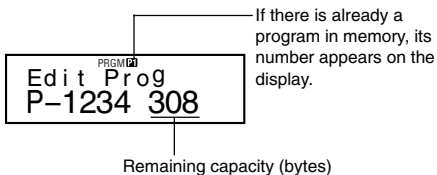3 (PCL) .... Clear Prog Mode for deleting programs.

Storing a Program

Use the following procedure to specify the Edit Prog Mode and store a program in memory.

Edit Prog .... [MODE] [MODE] [MODE] [1]

• **Example:** To create a program that uses Heron's formula to calculate the area of a triangle based on the lengths of its three sides

Formula: $S = \sqrt{s(s - A)(s - B)(s - C)}$ Note that: $s = (A + B + C)/2$.

1. Enter the Edit Prog Mode, which displays the screen shown below.

```
 PRGM P1
Edit Prog
P-1234 308
```

If there is already a program in memory, its number appears on the display.

Remaining capacity (bytes)

2. Select the program number (P1 to P4) to which you want to assign the program.

Ex.: [2] (Program P2)

```
 PRGM P2
—
 000
```

Number of bytes used by program P2.
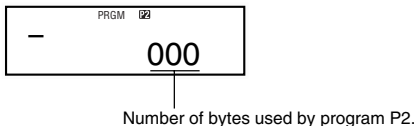
3. Input the program.

Program

$? \rightarrow A: ? \rightarrow B: ? \rightarrow C: (A + B + C) \div 2 \rightarrow D \blacktriangleleft D \times (D - A) \times (D - B) \times (D - C):$
$\sqrt{} Ans$

• To input a colon (:), press [EXE].
• To input "→A", press [SHIFT] [STO] [A].
• You can also input a variable name using the [ALPHA] key. To input "X" for example, press [ALPHA] [X].

E-36

- To input a question mark (?), right arrow (→), colon (:), or output command (⊿), press ⌨ P·CMD, and then use number keys ① through ④ to select the mark or command you want. See "Useful Program Commands" on page 40 for more information.

4. Press AC MODE MODE MODE ② to exit program input.

• Program Storage Notes

- Use the syntax below to prompt for input of a value by the person running the program, which will be assigned to the variable whose name is indicated by the program.
  ?→ <variable name>
  You can normally specify the variable names A, B, C, D, X, Y, and M (independent memory). In the CMPLX Mode, however, you can use only A, B, C, or M, because the other variables are used to store mode data.
- Use a colon (:) to link statements into multi-statements. A "statement" can be a calculation expression or function (such as Fix 3 or Deg). Note that you do not need to include a colon (:) at the end of the program.
- If you want execution of a program to pause at any point part way through, insert an output command (⊿) at the end of a statement instead of a colon (:). Note that you do not need to include an output command (⊿) at the end of the program.
- You can also specify a mode when inputting a program. The mode you specify is stored along with the program. You can specify different modes for programs P1, P2, P3, and P4. While the Edit Prog screen in step 1 under "Storing a Program" (page 36) is on the display, use the MODE key to specify the mode you want. The following are the modes that you can specify for a program: **COMP, CMPLX, SD*, REG*, BASE**.
  * Data input for statistical calculations is always retained in memory, even after calculation is complete. Statistical data remaining in memory can cause calculation errors when you run a program that includes statistical calculations. Because of this, you should press ⌨ CLR ① (Scl) EXE before executing such a program, or you should include the Scl command at the beginning of the program to make sure that statistical data memory is cleared.
- During program input, the cursor normally appears as a flashing underline mark (_). When there are eight bytes or less of memory remaining, however, the cursor changes to a flashing black box (■). If the remainder of the program you are inputting is larger than remaining memory

capacity, you will need to free up more memory capacity by deleting programs or statistical data you no longer need.
• See page 44 for information about how bytes are counted and how memory is shared by statistical data.

■Editing a Program

• While a program's contents are on the display in the Edit Prog Mode, you can use ◀ and ▶ to move the cursor to the location you want to edit.
• Press DEL to delete the function at the current cursor location.
• Use the insert cursor (page 9) when you want to insert a new statement into a program.

Executing a Program   RUN

The procedure in this section shows how to execute a program in the COMP Mode.

Perform the following key operation to enter the COMP Mode.
COMP .... MODE 1

• **Example:** To create a program that uses Heron's formula to calculate the area of a triangle whose three sides measure A = 30, B = 40, C = 50

1. Execute the program.
   (In the COMP Mode) Prog 2

   Specify the number of the program you want to execute.

2. Input the values required for the calculation.

   A?   30 EXE
   B?   40 EXE
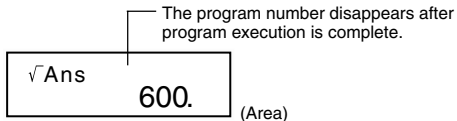   C?   50 EXE

   $$(A+B+C) \div 2 \to D$$
   $$60.$$ Disp

   (Assigns the result of
   $D = (A + B + C) \div 2$ to
   variable D.)

E-38

3. Press [EXE] to resume program execution.

The program number disappears after program execution is complete.

```
√Ans
                600.
```
(Area)

• Program Execution Notes

- Pressing [EXE] after program execution finishes causes the same program to be executed again.
- You can also run a program from the Run Prog screen by using number keys [1] through [4] to specify a program number (P1 through P4). You can display the Run Prog screen by pressing [AC] [EXE] from the Edit Prog screen after step 3 of the procedure under "Storing a Program" on page 36.
- You can use the following keys on the currently displayed value while program execution is paused by the output command (◢).
  [ENG], [·⁀·], [a⁄c], [Re↔Im], [MODE]*

  * Note that you can use the [MODE] key to select the settings shown below only. Program execution is automatically cancelled if you try to select any other mode or setting.

    Deg, Rad, Gra, Fix, Sci, Norm, Dec, Hex, Bin, Oct
- To cancel further program execution, press [AC].

• Errors During Program Execution

- If an error message appears on the display during program execution, press the ◀ or ▶ key to automatically enter the Edit Prog Mode. The location of the error with the cursor located there will appear on the display at this time. Determine the cause of the error and edit the program as required.
- Pressing the [AC] key while an error message is on the display clears the message and terminates program execution.

Deleting a Program `PCL`

> Use the following procedure to specify the Clear Prog Mode and delete a program from memory.
>
> Clear Prog .... [MODE] [MODE] [MODE] [3]

- You can also enter the Clear Prog Mode by pressing [DEL] while the Edit Prog screen is on the display.
- You can select programs individually by specifying a program number from P1 through P4.

1. Enter the Clear Prog Mode, which displays the screen shown below.

$$\begin{array}{l} \text{\tiny PRGM P1 P2} \\ \texttt{Clear Prog} \\ \texttt{P-1234 247} \end{array}$$

2. Select the program number (P1 to P4) of the program you want to delete.

- **Example:** [1] (Program P1)
- The number of the program you selected disappears from the upper part of the display, and remaining memory capacity increases by the size of the deleted program.
- Note that the only way to delete all the programs in memory (P1 through P4) is to perform the reset operation (page 11).

Useful Program Commands

In addition to mathematical calculations, there are also a number of useful program commands you can use to perform loops and define conditions.

■Program Command Menus

Press [SHIFT] [P-CMD] to display a menu of available program commands.
- The program command menu has three screens. Use the ◀ and ▶ keys to display the menu screen you want.
- To input one of the commands currently on the screen, press a number key from [1] through [5].

• Basic Commands

$$\begin{matrix} ? & \rightarrow & & : & \blacktriangleleft & \rightarrow \\ 1 & 2 & & 3 & 4 \end{matrix}$$

- 1 (?) .... Operator input command
- 2 ($\rightarrow$) .... Assign to variable command
- 3 (:) .... Multi-statement separator code
- 4 ($\blacktriangleleft$) .... Output command

• Conditional Jump Commands

$$\begin{matrix} \leftarrow \Rightarrow & = & \neq & > & \geq & \rightarrow \\ 1 & 2 & 3 & 4 & 5 \end{matrix}$$

- 1 ($\Rightarrow$) .... Jump code (when condition is met)
- 2 (=) .... Relational operator
- 3 ($\neq$) .... Relational operator
- 4 (>) .... Relational operator
- 5 ($\geq$) .... Relational operator

• Unconditional Jump Commands

$$\begin{matrix} \leftarrow \text{Goto} & \text{Lbl} \\ 1 & 2 \end{matrix}$$

- 1 (Goto) .... Jump command
- 2 (Lbl) .... Label

■ Unconditional Jump

- When the unconditional jump command (Goto *n*) is executed, processing jumps to the label (Lbl *n*) whose *n* value matches the *n* value of the unconditional jump command. You can specify an integer from 0 to 9 for *n*.
- You can also use the unconditional jump command and label to create an unconditional loop, which repeat a part of the program a specific number of times. To do this, put a label (such as Lbl 1, which is used in the example below) at the beginning of the part you want to repeat, and end the repeated part with an unconditional jump command (Goto 1, in the example).

- **Example:** Use Heron's formula to perform a series of calculations to determine the area of triangles for which the length of side A is fixed, and the lengths of sides B and C are variable.

  Program

  $?→A:$ Lbl 1: $?→B: ?→C: (A + B + C) ÷ 2→D$ ◢ $D × (D - A) × (D - B) ×$ $(D - C):$ $\sqrt{ }$ Ans ◢ Goto 1

■ Conditional Jump Using a Relational Operator

You can use relational operators so program execution compares two values and then decides which processing should be performed based on the relationship between the two values.

- **Example:** To create a program that calculates the total of a series of input values, with calculation being terminated whenever zero is input

  Program

  $\underset{①}{0→B:}$ Lbl 1: $\underset{②}{?→A:}$ $\underset{\text{Statement 1}\quad\text{Statement 2}}{\underbrace{A = 0 ⇒ \text{Goto 2}:\ B + A →B: \text{Goto 1}: \text{Lbl 2}: B}}$

  ③

  ① Assigns 0 to variable B.
  ② Assigns the input value to variable A.
  ③ If A = 0 is true, Statement 1 (Goto 2) is executed. If false, execution advances to Statement 2 without executing Statement 1.

• Relational Operator Notes

- The relational operators you can use in a program are: $=$, $\neq$, $>$, $\geq$.
- A relational operation that is true returns a value of 1, while a false relational operation returns a value of 0. For example, executing $3 = 3$ would return a result of 1, while $1 > 3$ returns a result of 0.

■ Other Program Statements

• [MODE] Key Settings

The items shown below can be included as statements inside of a program. You can input one of these statements using the same procedure as you do for normal calculation. That is, press the [MODE] key to display a selection screen and then press the number key that corresponds to the setting you want.

Deg, Rad, Gra, Fix, Sci, Norm, Dec, Hex, Bin, Oct

- **Example:** Deg: Fix 3

E-42

• Inputting Statistical Data

If you select the SD Mode or REG Mode before specifying a program number (P1 through P4), you can input statistical data as part of your program.

- Input statistical data using the $\boxed{\text{DT}}$ key, just as you normally do (page 25).
- In addition to values, you can also input calculation expressions as data.

- **Example 1:** To determine $\bar{x}$ of the following data ($\bar{x}$ **= 30.875**)

x	Frequency
30	2
27	1
32	5

(SD Mode) Scl: 30; 2 DT: 27 DT: 32; 5 DT: $\bar{x}$
                            *

* You do not need to specify the frequency when inputting a data item that has a single occurrence.

- **Example 2:** To determine regression coefficients A, B, and C for the following data (**A = 3, B = –2, C = 1**)

x	y	Frequency
3	6	2
4	11	1
6	27	2

(REG (Quad) Mode) Scl: 3,6; 2 DT: 4,11 DT: 6,27; 2 DT: A◢B◢C
                              *   **

**A, B, and C are not variable names. They are regression coefficients.

• Memory Calculations

You can perform memory calculations in a program by inserting **M**+ and **M**–.

- **Example:** ... : 2 × 3 M+ : ...

• Percent Calculations

You can perform percent calculations in a program by inserting **%**.

- **Example:** ... : 250 + 280 % : ...

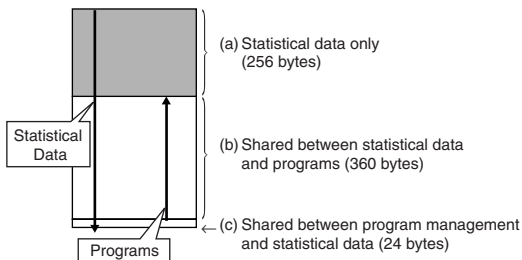Note that you cannot perform percent calculations like the following in a program: $a \times b$%+, $a \times b$%–.

• Rnd

You can round a value by using **Rnd** in a program.

- **Example:** 1 ÷ 3 : Rnd: ...

Statistical Data Memory and Program Memory

The following shows how the calculator uses memory for storage of statistical data and programs.

(a) Statistical data only (256 bytes)

Statistical Data

(b) Shared between statistical data and programs (360 bytes)

← (c) Shared between program management and statistical data (24 bytes)

Programs

■Statistical Data

• Each x-data or y-data (for regression calculations) item and each frequency value (other than 1) that you input uses up eight bytes of memory.

   Example: Inputting the following in the SD Mode uses 40 bytes of memory: 30 [SHIFT] [;] 2 [DT] 27 [SHIFT] [;] 1 [DT] 32 [SHIFT] [;] 5 [DT]

• The memory area indicated as (a) in the above illustration is exclusively for statistical data items. Since this area has 256 bytes, it can contain up to 32 individual (frequency = 1) x-data items (256 bytes ÷ 8 bytes per data item = 32).

• When memory area (a) becomes full, statistical data items are stored in the free space (space not being used for program storage) of memory area (b), if there is any. If there are no programs currently stored in memory, memory area (c) is also used to store statistical data items. Memory areas (a), (b), and (c) have a total capacity of 640 bytes, so there is enough total memory to store up to 80 individual (frequency = 1) x-data items (640 bytes ÷ 8 bytes per data item = 80).

- Trying to input a data item that takes up more bytes than are currently available in memory area (b) causes the message "Data Full" to appear on the display. If this happens, you can press [EXE] [1] to select "EditOFF." Though this will allow you to input more statistical data items (and free up memory area (b) for program storage), it also deletes the data items that are currently stored in memory areas (a) and (b). Also, the data items you input after pressing [EXE] [1] will not be saved. This means you will not be able to view or edit individual data items after you input them.
- To input new statistical data when editing is turned off (EditOFF), press [SHIFT] [CLR] [1] (Scl) [EXE] to delete statistical data currently stored in memory and turn editing on (EditON). You will be able to input statistical data into the statistical data area (a) and the program memory area (b) that does not contain program data. You can also delete program data you no longer need to free up space for further statistical data input.

■Programs

- Each function you input into program memory takes up either one byte or two bytes of memory, as shown below.
  - 1-byte Functions: sin, cos, log, (,), :, ◢, A, B, C, 1, 2, Fix 3 etc.
  - 2-byte Functions: Goto 1, Lbl 2 etc.
- Pressing ◀ or ▶ while a program is on the display causes the cursor to jump one byte in the direction indicated by the arrow.
- Inputting the first program while there are no other programs in memory causes 24 bytes of memory to be reserved automatically as a program management area (area (c) on page 44).
- A newly input program is stored in free space (space not currently being used for program storage or statistical data storage) that is available in the program memory area (area (b) on page 44). All 360 bytes of the program memory area are available for program storage when there is no statistical data stored in the program memory area.

Technical Information

■When you have a problem......

If calculation results are not what you expect or if an error occurs, perform the following steps.

1. Press [SHIFT] [CLR] [2] (Mode) [EXE] to initialize all modes and settings.
2. Check the formula you are working with to confirm it is correct.
3. Enter the correct mode and try performing the calculation again.

If the above steps do not correct the problem, press the [ON] key. The calculator performs a self-check operation and deletes all data stored in memory if any abnormality is detected. Make sure you always keep written copies of all important data.

■Error Messages

The calculator is locked up while an error message is on the display. Press [AC] to clear the error, or press [◀] or [▶] to display the calculation and correct the problem. See "Error Locator" for details.

Math ERROR

- **Causes**
  - Calculation result is outside the allowable calculation range.
  - An attempt to perform a function calculation using a value that exceeds the allowable input range.
  - An attempt to perform an illogical operation (division by zero, etc.)

- **Action**
  - Check your input values and make sure they are all within the allowable ranges. Pay special attention to values in any memory areas you are using.

Stack ERROR

- **Cause**
  - The capacity of the numeric stack or operator stack is exceeded.

- **Action**
  - Simplify the calculation. The numeric stack has 10 levels and the operator stack has 24 levels.

• Divide your calculation into two or more separate parts.

Syntax ERROR

- **Cause**
  - A calculation formula or program formula contains an error.
  - There is a colon (:) or output command (◢) at the end of the program.

- **Action**
  - Press ◀ or ▶ to display the calculation with the cursor located at the location of the error and make required corrections.
  - Delete the colon (:) or output command (◢) at the end of the program.

Arg ERROR

- **Cause**
  - Improper use of an argument

- **Action**
  - Press ◀ or ▶ to display the location of the cause of the error and make required corrections.

Go ERROR

- **Cause**
  - A Goto *n* command does not have a corresponding Lbl *n* label.

- **Action**
  - Correctly input an Lbl *n* label that corresponds to the existing Goto *n* command, or delete the Goto *n* command if it is not required.

■ Order of Operations

Calculations are performed in the following order of precedence.

① Coordinate transformation: Pol (*x*, *y*), Rec (*r*, *θ*)
   Differentials: *d/dx*
   Integrations: $\int dx$

② Type A functions:
   With these functions, the value is entered and then the function key is pressed.
   x^3, x^2, x^{-1}, $x!$, ° ' "
   $\hat{x}$, $\hat{x}_1$, $\hat{x}_2$, $\hat{y}$

Angle unit conversions (DRG►)

③ Powers and roots: $^\wedge(x^y)$, $^x\sqrt{}$

④ a^b/c

⑤ Abbreviated multiplication format in front of π, e (natural logarithm base), memory name, or variable name: 2π, $3e$, $5A$, πA, etc.

⑥ Type B functions:

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

$\sqrt{}$, $^3\sqrt{}$, log, ln, e^x, 10^x, sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, $(-)$, d, h, b, o, Neg, Not, arg, Abs, Conjg

⑦ Abbreviated multiplication format in front of Type B functions: $2\sqrt{3}$, Alog2, etc.

⑧ Permutation and combination: $n\text{P}r$, $n\text{C}r$

$\angle$

⑨ $\times$, $\div$

⑩ $+$, $-$

⑪ $>$, $\geqq$

⑫ $=$, $\neq$

⑬ and

⑭ xnor, xor, or

- Operations of the same precedence are performed from right to left.
  $e^x\ln\sqrt{}120 \rightarrow e^x\{\ln(\sqrt{}120)\}$
- Other operations are performed from left to right.
- Operations enclosed in parentheses are performed first.
- When a calculation contains an argument that is a negative number, the negative number must be enclosed within parentheses. The negative sign $(-)$ is treated as a Type B function, so particular care is required when the calculation includes a high-priority Type A function, or power or root operations.

Example: $(-2)^4 = 16$

$-2^4 = -16$

■Stacks

This calculator uses memory areas, called "stacks," to temporarily store values (numeric stack) and commands (command stack) according to their precedence during calculations. The numeric stack has 10 levels and the command stack has 24 levels. A stack error (Stack ERROR) occurs whenever you try to perform a calculation that is so complex that the capacity of a stack is exceeded.

• **Example:** $2 \times ((3 + 4 \times (5 + 4) \div 3) \div 5) + 8 =$
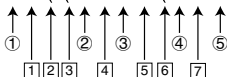
Numeric Stack		**Command Stack**	
①	**2**	1	×
②	**3**	2	(
③	**4**	3	(
④	**5**	4	+
⑤	**4**	5	×
⋮		6	(
		7	+
		⋮	

• Calculations are performed in sequence according to "Order of Operations." Commands and values are deleted from the stack as the calculation is performed.

■ Input Ranges

Internal digits: 12
Accuracy*: As a rule, accuracy is ±1 at the 10th digit.

Functions		Input Range
$\sin x$	DEG	$0 \leq |x| \leq 4.499999999 \times 10^{10}$
	RAD	$0 \leq |x| \leq 785398163.3$
	GRA	$0 \leq |x| \leq 4.999999999 \times 10^{10}$
$\cos x$	DEG	$0 \leq |x| \leq 4.500000008 \times 10^{10}$
	RAD	$0 \leq |x| \leq 785398164.9$
	GRA	$0 \leq |x| \leq 5.000000009 \times 10^{10}$
$\tan x$	DEG	Same as $\sin x$, except when $|x| = (2n-1) \times 90$.
	RAD	Same as $\sin x$, except when $|x| = (2n-1) \times \pi/2$.
	GRA	Same as $\sin x$, except when $|x| = (2n-1) \times 100$.
$\sin^{-1} x$		$0 \leq |x| \leq 1$
$\cos^{-1} x$		
$\tan^{-1} x$		$0 \leq |x| \leq 9.999999999 \times 10^{99}$
$\sinh x$		$0 \leq |x| \leq 230.2585092$
$\cosh x$		
$\sinh^{-1} x$		$0 \leq |x| \leq 4.999999999 \times 10^{99}$
$\cosh^{-1} x$		$1 \leq x \leq 4.999999999 \times 10^{99}$
$\tanh x$		$0 \leq |x| \leq 9.999999999 \times 10^{99}$
$\tanh^{-1} x$		$0 \leq |x| \leq 9.999999999 \times 10^{-1}$
$\log x / \ln x$		$0 < x \leq 9.999999999 \times 10^{99}$
10^x		$-9.999999999 \times 10^{99} \leq x \leq 99.99999999$
e^x		$-9.999999999 \times 10^{99} \leq x \leq 230.2585092$
$\sqrt{x}$		$0 \leq x < 1 \times 10^{100}$
x^2		$|x| < 1 \times 10^{50}$
$1/x$		$|x| < 1 \times 10^{100} ; x \neq 0$
$\sqrt[3]{x}$		$|x| < 1 \times 10^{100}$

Functions	Input Range
$x!$	$0 \leqq x \leqq 69$ (x is an integer)
$n\text{P}r$	$0 \leqq n < 1 \times 10^{10}$, $0 \leqq r \leqq n$ (n, r are integers) $1 \leqq \{n!/(n-r)!\} < 1 \times 10^{100}$
$n\text{C}r$	$0 \leqq n < 1 \times 10^{10}$, $0 \leqq r \leqq n$ (n, r are integers) $1 \leqq [n!/\{r!(n-r)!\}] < 1 \times 10^{100}$
Pol (x, y)	$|x|$, $|y| \leqq 9.999999999 \times 10^{49}$ $(x^2+y^2) \leqq 9.999999999 \times 10^{99}$
Rec(r, θ)	$0 \leqq r \leqq 9.999999999 \times 10^{99}$ θ: Same as $\sin x$
° ' "	$\|a\|$, b, $c < 1 \times 10^{100}$ $0 \leqq b$, c
$\overleftarrow{° ' "}$	$\|x\| < 1 \times 10^{100}$ Decimal ↔ Sexagesimal Conversions $0°0°0° \leqq \|x\| \leqq 999999°59°$
$\wedge(x^y)$	$x>0$: $-1 \times 10^{100} < y\log x < 100$ $x=0$: $y>0$ $x<0$: $y=n$, $\dfrac{m}{2n+1}$ (n, m are integers) However: $-1 \times 10^{100} < y\log\|x\| < 100$
$\sqrt[x]{y}$	$y>0$: $x \neq 0$, $-1 \times 10^{100} < 1/x \log y < 100$ $y=0$: $x>0$ $y<0$: $x=2n+1$, $\dfrac{1}{n}$ ($n \neq 0$; n is an integer) However: $-1 \times 10^{100} < 1/x \log\|y\| < 100$
a^b/c	Total of integer, numerator, and denominator must be 10 digits or less (including division marks).
SD (REG)	$\|x\| < 1 \times 10^{50}$ $\|y\| < 1 \times 10^{50}$ $\|n\| < 1 \times 10^{100}$ $x\sigma n$, $y\sigma n$, $\bar{x}$, $\bar{y}$: $n \neq 0$ $x\sigma n-1$, $y\sigma n-1$, A, B, r : $n \neq 0$, 1

* For a single calculation, calculation error is ±1 at the 10th digit. (In the case of exponential display, calculation error is ±1 at the last significant digit.) Errors are cumulative in the case of consecutive calculations, which can also cause them to become large. (This is also true of internal consecutive calculations that are performed in the case of $\wedge(x^y)$, $\sqrt[x]{y}$, $x!$, $\sqrt[3]{}$, nPr, nCr, etc.)

In the vicinity of a function's singular point and point of inflection, errors are cumulative and may become large.

Power Supply

The type of battery you should use depends on the model number of your calculator.

fx-3650P

The TWO WAY POWER system actually has two power supplies: a solar cell and a G13 Type (LR44) button battery. Normally, calculators equipped with a solar cell alone can operate only when relatively bright light is present. The TWO WAY POWER system, however, lets you continue to use the calculator as long as there is enough light to read the display.

• Replacing the Battery

Either of the following symptoms indicates battery power is low, and that the battery should be replaced.

• Display figures are dim and difficult to read in areas where there is little light available.
• Nothing appears on the display when you press the ON key.

• To replace the battery

① Remove the six screws that hold the back cover in place and then remove the back cover.

② Remove the old battery.

③ Wipe off the sides of new battery with a dry, soft cloth. Load it into the unit with the positive $\oplus$ side facing up (so you can see it).

④ Replace the back cover and secure it in place with the six screws.

⑤ Press ⟨ON⟩ to turn power on. Be sure not to skip this step.

Screw   Screw
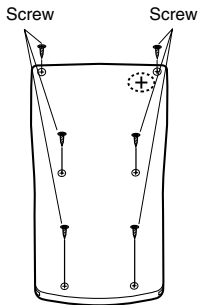
fx-3950P

This calculator is powered by single G13 Type (LR44) button battery.

• Replacing the Battery

Dim figures on the display of the calculator indicate that battery power is low. Continued use of the calculator when the battery is low can result in improper operation. Replace the battery as soon as possible when display figures become dim.

• To replace the battery

① Press ⟨SHIFT⟩ ⟨OFF⟩ to turn off power.

② Remove the screw that holds the battery cover in place and then remove the battery cover.

③ Remove the old battery.

④ Wipe off the sides of new battery with a dry, soft cloth. Load it into the unit with the positive $\oplus$ side facing up (so you can see it).

⑤ Replace the battery cover and secure it in place with the screw.

⑥ Press ⟨ON⟩ to turn power on.

Screw
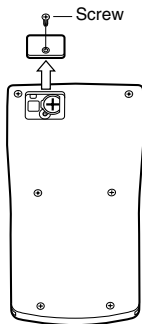
Auto Power Off

Calculator power automatically turns off if you do not perform any operation for about six minutes. When this happens, press $\boxed{\text{ON}}$ to turn power back on.

Specifications

Power Supply:
   fx-3950P: Single G13 Type button battery (LR44)
   fx-3650P: Solar cell and a single G13 Type button battery (LR44)

Battery Life:
   fx-3950P: Approximately 9,000 hours continuous display of flashing cursor.
   Approximately 3 years when left with power turned off.
   fx-3650P: Approximately 3 years (1 hour use per day).

Dimensions: 11.8 (H) $\times$ 80 (W) $\times$ 159 (D) mm
   $7/16''$ (H) $\times$ $31/8''$ (W) $\times$ $61/4''$ (D)

Weight: 100 g (3.5 oz) including battery

Power Consumption: 0.0002 W

Operating Temperature: 0°C to 40°C (32°F to 104°F)

Practical Examples/Ejemplos prácticos

■ Program Library   ■ Biblioteca de programas

Problem: Quadratic Equation

Create a program that solves the quadratic equation $ax^2 + bx + c = 0$ for x, when values are provided for a, b, and c.

Problema: Ecuación cuadrática

Crear un programa que resuelva la ecuación cuadrática $ax^2 + bx + c = 0$ para x, cuando se proporcionan valores para a, b y c.

$$x = (-b \pm \sqrt{b^2 - 4ac})/2a \quad (b^2 - 4ac \geqq 0)$$

Program

Press MODE MODE MODE 1 to display the Edit Prog screen. Input a value from 1 to 4 to select a program number (P1 through P4), and then input the program below.

Programa

Presione MODE MODE MODE 1 para visualizar la pantalla Edit Prog. Ingrese un valor de 1 a 4 para seleccionar un número de programa (P1 a P4), y luego ingrese el programa siguiente.

Lbl 0: ? → A: ? → B: ? → C: Bx^2 − 4AC → D: D = 0 ⇒ Goto 1: D > 0 ⇒ Goto 2: Goto 0: Lbl 2: (− B − $\sqrt{}$D) ÷ (2A) → X: X ◢ Lbl 1: (− B + $\sqrt{}$D) ÷ (2A) → X: X

Program Execution / Ejecución de programa

Display / Presentación	Operation / Operación
	`Prog` `1` (Example: Program P1) (Ejemplo: Programa P1)
A?	2 `EXE`
B?	`(−)` 7 `EXE`
C?	6 `EXE`
$X = 1.5$ (Value appears in line 2 of display.) (El valor aparece en la línea 2 de la presentación.)	`EXE`
$X = 2$ (Value appears in line 2 of display.) (El valor aparece en la línea 2 de la presentación.)	

Problem: Solution of a Triangle when Two Sides and Their Angle are Known

**Problema:** Solución de un triángulo cuando se conocen dos lados y su ángulo.

Create a program that calculates the remaining side and two angles of a triangle when the length of two sides (*a*, *b*) and the angle they form (γ) are known.

Crear un programa que calcule el lado restante y dos ángulos de un triángulo, cuando se conocen la longitud de los dos lados (*a* y *b*) y el ángulo que forman (γ).
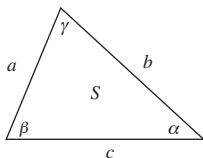
$$S = \frac{1}{2} bc \sin \alpha$$

$$\cos \alpha = \frac{b^2 + c^2 - a^2}{2bc}$$
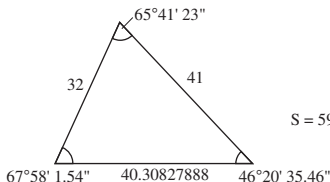
$$S = 597.8321153$$

Program

Press [MODE] [MODE] [MODE] [1] to display the Edit Prog screen. Input a value from 1 to 4 to select a program number (P1 through P4), and then input the program below.

Programa

Presione [MODE] [MODE] [MODE] [1] para visualizar la pantalla Edit Prog. Ingrese un valor de 1 a 4 para seleccionar un número de programa (P1 a P4), y luego ingrese el programa siguiente.

Deg: ? → A: ? → B: ? → D: A × B × sin D ÷ 2 ◢ Ans → X: $\sqrt{\ }$ (A x^2 + B x^2 − cos D × 2 × A × B) → C ◢ sin⁻¹ (X × 2 ÷ B ÷ C) → Y: Y > 90 ⇒ Bx^2 + Cx^2 > Ax^2 ⇒ Y − 90 → Y: 90 > Y ⇒ Ax^2 > Bx^2 + Cx^2 ⇒ Y + 90 → Y: Y ◢ 180 − Y − D

A-3

Program Execution / Ejecución de programa

Display / Presentación	Operation / Operación
	`Prog` `2` (Example: Program P2)
	(Ejemplo: Programa P2)
A?	32 `EXE`
B?	41 `EXE`
D?	65 `⋯` 41 `⋯` 23 `⋯` `EXE`
597.8321153 (Area)/(Area)	`EXE`
40.30827888 (Length of side c)	`EXE`
(Longitud de lado c)	
46.34318362 (Angle α)/(Angulo α)	`SHIFT` `⋯`
46°20°35.46	`EXE`
67.96709416 (Angle β)/(Angulo β)	`SHIFT` `⋯`
67°58°1.54	

Note

• The conditional jump in the latter part of the program performs a process that determines whether angle α is an acute angle or an obtuse angle. First it checks whether the sum of the squares of side b and side c, which form angle α, is greater than or less than the square of side a. That way it can tell if angle α is an acute angle or an obtuse angle. Next, it uses the formula $S = \frac{1}{2} bc \sin \alpha$ to determine whether the result matches the value calculated for α. If it does not match, it changes the value of α to an acute angle if it is currently an obtuse angle, or to an obtuse angle if it is currently an acute angle.

Nota

• El salto condicional en la parte posterior del programa realiza un proceso que determina si un ángulo α es un ángulo agudo o un ángulo obtuso. Primero verifica si la suma de los cuadrados del lado b y lado c, que forman el ángulo α, es mayor o menor que el cuadrado del lado a. De esta manera puede indicar si un ángulo α es un ángulo agudo o un ángulo obtuso. Luego, utiliza la fórmula $S = \frac{1}{2} bc \text{ sen } \alpha$ para determinar si el resultado coincide con el valor calculado para α. Si no coincide, cambia el valor de α a un ángulo agudo si actualmente es un ángulo obtuso, o a un ángulo obtuso si actualmente es un ángulo agudo.

CASIO