SHARP

EL-5230
EL-5250

PROGRAMMABLE SCIENTIFIC CALCULATOR

OPERATION MANUAL

SHARP EL-5230/5250

Programmable Scientific Calculator

Contents

Introduction

Thank you for purchasing the SHARP Programmable Scientific Calculator Model EL-5230/5250.
After reading this manual, store it in a convenient location for future reference.

- Unless the model is specified, all text and other material appearing in this manual applies to both models (EL-5230 and EL-5250).
- Either of the models described in this manual may not be available in some countries.
- Screen examples shown in this manual may not look exactly the same as what is seen on the product. For instance, screen examples will show only the symbols necessary for explanation of each particular calculation.
- All company and/or product names are trademarks and/or registered trademarks of their respective holders.

Operational Notes

- 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 fragile.
- 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. Do not use solvents or a wet cloth.
- Do not drop it or apply excessive force.
- Never dispose of batteries in a fire.
- Keep batteries out of the reach of children.
- This product, including accessories, may change due to upgrading without prior notice.

NOTICE

- **SHARP strongly recommends that separate permanent written records be kept of all important data. Data may be lost or altered in virtually any electronic memory product under certain circumstances. Therefore, SHARP assumes no responsibility for data lost or otherwise rendered unusable whether as a result of improper use, repairs, defects, battery replacement, use after the specified battery life has expired, or any other cause.**
- **SHARP will not be liable nor responsible for any incidental or consequential economic or property damage caused by misuse and/or malfunctions of this product and its peripherals, unless such liability is acknowledged by law.**

Key Notation in This Manual

In this manual, key operations are described as follows:

To specify e^x : [2ndF] [e^x] ..... ①
To specify ln : [ln]
To specify F : [ALPHA] F ..... ②

To specify d/c : [2ndF] [d/c] ..... ①
To specify $a^{b/c}$: [$a^{b/c}$]
To specify H : [ALPHA] H ..... ②
To specify i : [*i*] ..... ③

① Functions that are printed in orange above the key require [2ndF] to be pressed first before the key.
② When you specify the memory (printed in blue above the key), press [ALPHA] first.
Alpha-numeric characters for input are not shown as keys but as regular alpha-numeric characters.
③ Functions that are printed in grey (gray) adjacent to the keys are effective in specific modes.

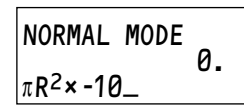
Note:

- To make the cursor easier to see in diagrams throughout the manual, it is depicted as '_' under the character though it may actually appear as a rectangular cursor on the display.

Example

Press [ON/C] [2ndF] [π] [ALPHA] R
[x^2] [×] [(−)] 10

- [2ndF] [π] and [ALPHA] R means you have to press [2ndF] followed by [Exp] key and [ALPHA] followed by [5] key.



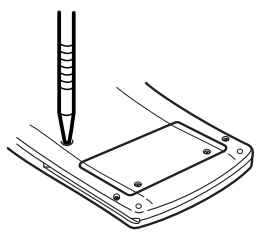
Chapter 1
Before You Get Started

Preparing to Use the Calculator

Before using your calculator for the first time, you must reset it and adjust its contrast.

Resetting the calculator

1. Press the RESET switch located on the back of the calculator with the tip of a ball-point pen or similar object. Do not use an object with a breakable or sharp tip.



- If you do not see the message on the right, the battery may be installed incorrectly; refer to 'Battery Replacement' (See page 115.) and try installing it again.

```
ALL DATA CL?
 YES→[DEL]
  NO→[ENTER]
```

2. Press [DEL].

- The initial display of the NORMAL mode appears.

```
NORMAL MODE
                0.
```

3. Press [2ndF] [OPTION] [0] and press [+] or [−] to adjust the display contrast until it is set correctly, then press [ON/C].

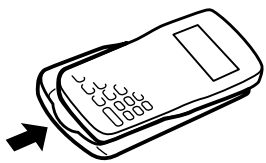
```
LCD CONTRAST
 [+]    [−]
DARK←  →LIGHT
```

- [2ndF] [OPTION] means you have to press [2ndF] followed by [(−)] key.
- See 'The OPTION menu' (See page 118.) for more information regarding optional functions.

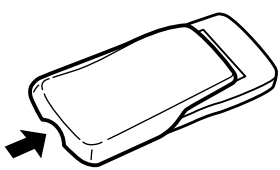
The Hard Case

Your calculator comes with a hard case to protect the keyboard and display when the calculator is not in use.

Before using the calculator, remove the hard case and slide it onto the back as shown to avoid losing it.

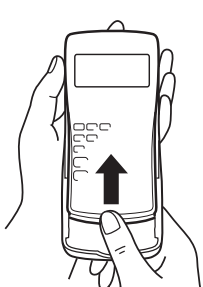


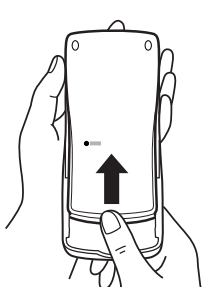
When you are not using the calculator, slide the hard case over the keyboard and display as shown.



- Firmly slide the hard case all the way to the edge.
- The quick reference card is located inside the hard case.

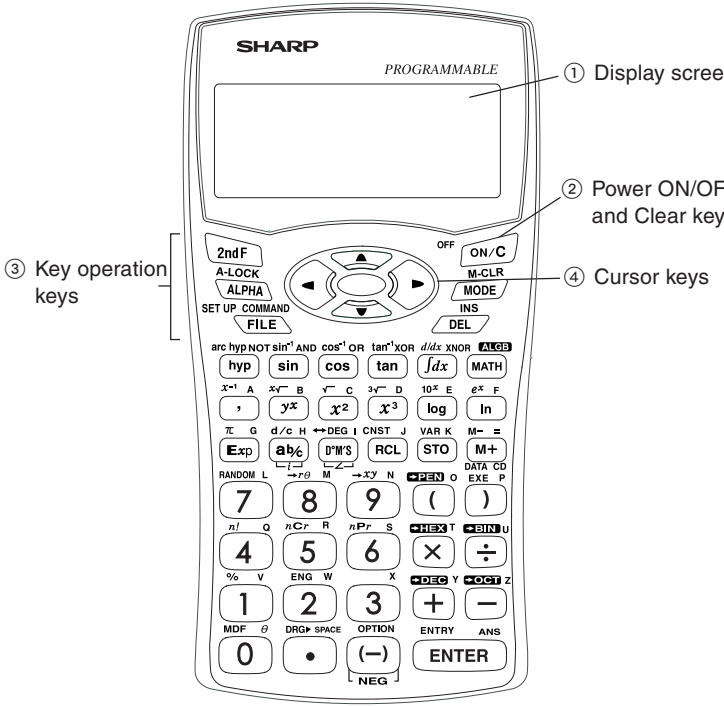
- Remove the hard case while holding with fingers placed in the positions shown below.





Calculator Layout and Display Symbols

Calculator layout



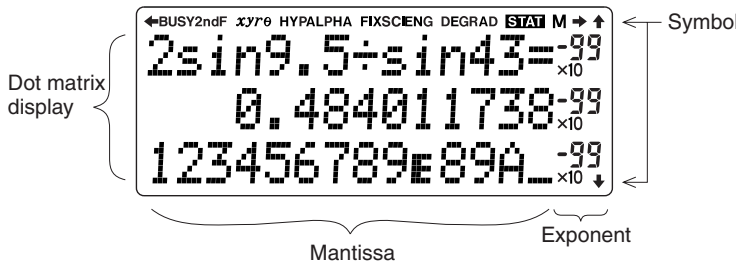
① **Display screen:** The calculator display consists of 14 × 3 line dot matrix display (5 × 7 dots per character) and a 2-digit exponent display per each line.

② **Power ON/OFF and Clear key:** Turns calculator ON. To turn off the calculator, press [2ndF], then [OFF]. This key can also be used to clear the display.

③ **Key operation keys:**
[2ndF]: Activates the second function (printed in orange) assigned to the next pressed key.
[ALPHA]: Activates the variable (printed in blue) assigned to the next pressed key.

④ **Cursor keys:** Enables you to move the cursor in four directions.

Display



- During actual use, not all symbols are displayed at the same time.
- Only the symbols required for the usage under instruction are shown in the display and calculation examples of this manual.

◀/▶ ▲/▼ : Indicates some contents are hidden in the directions shown. Press cursor keys to see the remaining (hidden) section.

BUSY : Appears during the execution of a calculation.

2ndF : Appears when [2ndF] is pressed.

xyl rθ : Indicates the mode of expression of results in the complex calculation mode.

HYP : Indicates that [hyp] has been pressed and the hyperbolic functions are enabled. If [2ndF] [arc hyp] are pressed, the symbols '**2ndF HYP**' appear, indicating that inverse hyperbolic functions are enabled.

ALPHA: Appears when [ALPHA], [2ndF] [A-LOCK], [STO] or [RCL] is pressed.

FIX/SCI/ENG: Indicates the notation used to display a value.

DEG/RAD/GRAD: Indicates angular units.

STAT : Appears when statistics mode is selected.

M : Indicates that a value is stored in the M memory.

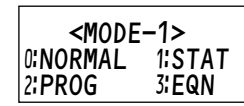
Operating Modes

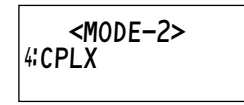
This calculator has five operating modes to perform various operations. These modes are selected from the MODE key.

Selecting a mode

1. Press [MODE].

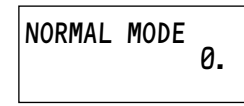
The menu display appears.
Press [▼] to display the next menu page.





2. Press [0] to select the NORMAL mode.

- In the menu display, press the assigned number to choose or recall a selection.



What you can do in each mode

NORMAL mode:
Allow you to perform standard scientific calculations, Differential/Integral functions, N-base calculations, Solver function, Simulation calculation.

STAT (statistics) mode:
Allows you to perform statistical calculations.

PROG (program) mode:
Allows you to create and use programs to automate simple or complex calculations.

EQN (equation) mode:
Allows you to perform equation solvers, such as quadratic equation.

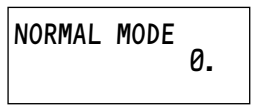
CPLX (complex) mode:
Allows you to perform arithmetic operations with complex numbers.

A Quick Tour

This section takes you on a quick tour covering the calculator's simple arithmetic operations and also principal features like the solver function.

Turning the calculator on and off

1. Press [ON/C] at the top right of the keypad to turn the calculator on.



- To conserve the batteries, the calculator turns itself off automatically if it is not used for several minutes.

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

- Whenever you need to execute a function or command which is written in orange above a key, press [2ndF] followed by the key.

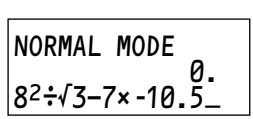
Entering and solving an expression

Arithmetic expressions should be entered in the same order as they would normally be written in. To calculate the result of an expression, press [ENTER] at the bottom right of the keypad; this has the same function as the 'equals' key on some calculators.

Example

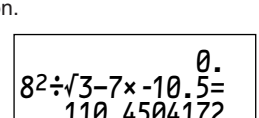
Find the answer to the expression
$8^2 \div \sqrt{3} - 7 \times$ -10.5

1. 8 [x^2] [÷] [2ndF] [$\sqrt{}$] 3 [−]
   7 [×] [(—)] 10.5



- This calculator has a minus key [−] for subtraction and a negative key [(—)] for entering negative numbers.
- To correct an error, use the cursor keys [◀] [▶] [▲] [▼] to move to the appropriate position on the display and type over the original expression.

2. Press [ENTER] to obtain an answer.



- While the calculator is computing an answer, BUSY is displayed at the above left of the display.
- The cursor does not have to be at the end of an expression for you to obtain an answer.

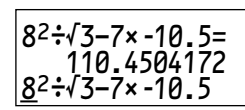
Editing an expression

After obtaining an answer, you can go back to an expression and modify it using the cursor keys just as you can before the [ENTER] is pressed.

Example

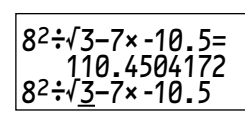
Return to the last expression and change it to $8^2 \div \sqrt{3 - 7 \times -10.5}$

1. Press [▼] or [▶] to return to the last expression.



- The cursor is now at the beginning of the expression (on '8' in this case).
- Pressing [▲] or [◀] after obtaining an answer returns the cursor to the end of the last expression.
- To make the cursor easier to see in diagrams throughout the manual, it is depicted as '_' under the character though it may actually appear as a rectangular cursor on the display.

2. Press [▶] four times to move the cursor to the point where you wish to make a change.

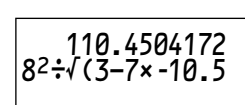


- The cursor has moved four places to the right and is now flashing over '3'.

3. Press [2ndF] [INS].

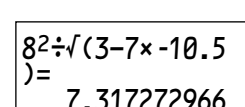
- This changes the character entering mode from 'overwrite' to 'insert'.
- When [2ndF] is pressed the 2ndF symbol should appear at the above of the display. If it does not, you have not pressed the key firmly enough.
- The shape of the flashing cursor tells you which character entering mode you are in. A triangular cursor indicates 'insert' mode while a rectangular cursor indicates 'overwrite' mode.

4. Press [(] and then move the cursor to the end of expression ([2ndF] [▶]).



- Note that the cursor has moved to the second line since the expression now exceeds 14 characters.

5. Press [)] and [ENTER] to find the answer for the new expression.



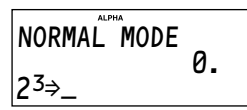
Using variables

You can use 27 variables (A-Z and θ) in the NORMAL mode. A number stored as a variable can be recalled either by entering the variable name or using [RCL].

Example 1

Store 2^3 to variable R.

1. Press [ON/C] 2 [x^3] then [STO].
- [ON/C] clears the display.
- ALPHA appears automatically when you press [STO]. You can now enter any alphabetic character or θ (written in blue above keys in the keypad).

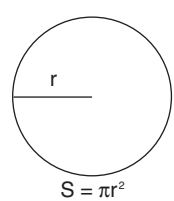


2. Press R to store the result of 2^3 in R.
- The stored number is displayed on the next line.
- ALPHA disappears from the display.

You can also store a number directly rather than storing the result of an expression.

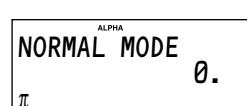
Example 2

Find the area of a circle which has radius R.

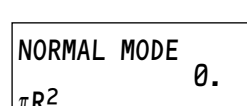


Enter an expression containing variable R (now equal to 8) from the last example.

1. Press [ON/C] [2ndF] [π] then [ALPHA].
- Whenever you need to use a character written in blue on the keypad, press [ALPHA] beforehand. ALPHA will appear at the above of the display.



2. Press R and then [x^2].
- ALPHA disappears after you have entered a character.



3. Press [ENTER] to obtain the result.
   Follow the same procedure as above, but press [RCL] instead of [ALPHA] in step 1.

   You will get the same result.

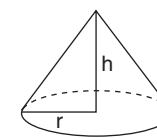
```
                    0.
πR²=
   201.0619298
```

Using simulation calculations (ALGB)

If you want to find more than one solution using the same formula or algebraic equation, you can do this quickly and simply by use of the simulation calculation.

Example

Find the volume of two cones:
① with height 10 and radius 8 and
② with height 8 and radius 9.



$$V = \frac{1}{3}\pi r^2 h$$

1. Press [ON/C] 1 [$a^b/_c$] 3 [2ndF] [π] [ALPHA] R [x^2] [ALPHA] H to enter the formula.

```
NORMAL MODE
                    0.
1⌐3πR²H_
```

- Note that '1⌐3' represents 1 over (i.e. divided by) 3.
- Variables can be represented only by capital letters.

2. Press [2ndF] [ALGB] ([MATH] key) to finish entering the equation.

```
1⌐3πR²H
H=                  0.  ↓
```

- The calculator automatically picks out the variables alphabetically contained in the equation in alphabetical order and asks you to input numbers for them.
- ↓ at the bottom of the display reminds you that there is another variable further on in the expression.

3. Press 10 [ENTER] to input the height and go on the next variable.

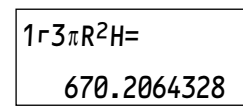
```
1⌐3πR²H                 ↑
R=                  8.
```

- The calculator is now asking you to input a number for the next variable.

- Note that, as the variable R already has a number stored in memory, the calculator recalls that number.
- ↑ indicates that there is another variable earlier in the expression.

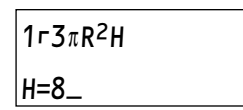
4. Press 8 to input the radius.
   Input of all variables is now complete.
5. Press [ENTER] to obtain the solution.

- The answer (volume of cone ①) is displayed on the third line.

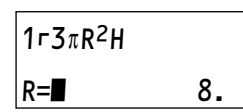


6. Press [ENTER] and 8 to input the height for cone ②.

- The display returns to a value entry screen with '8' substituted for '10' in variable H.

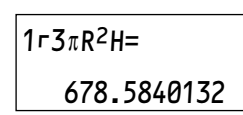


7. Press [ENTER] to confirm the change.



8. Press 9 to enter the new radius then press [ENTER] to solve the equation.

- The volume of cone ② is now displayed.
- In any step, press [2ndF] [EXE] to obtain the solution using the values entered into the variables at that time.

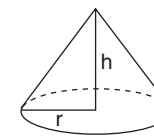


Using the solver function

You can solve any unknown variable in an equation by assigning known values to the rest of the variables. Let us compare the differences between the solver function and the simulation calculations using the same expression as in the last example.

Example

What is the height of cone ③ if it has a radius of 8 and the same volume as cone ② (r = 9, h = 8) in the last example?



$$V = \frac{1}{3}\pi r^2 h$$

9. Store the result of step 8 on the previous page in variable V.
   Press [ON/C] twice and [ALPHA] [ANS] [STO] V.

```
                0.
Ans⇒V
  678.5840132
```

10. Input the equation (including '=') in the NORMAL mode.
    Press [ALPHA] V [ALPHA] [=] then input the rest of the expression.
    You must press [ALPHA] [=] ([M+] key), not [ENTER], to enter the = sign.

```
Ans⇒V
  678.5840132
V=1r3πR²H_
```

11. Press [MATH] [5] to move to the variable input display.

```
V=1r3πR²H
H=                8.
```

- Note that the values assigned to the variables in the last example for the simulation calculations are retained and displayed.

12. Press [▼] to skip the height, and then press 8 [ENTER] to enter the radius (R).

```
V=1r3πR²H
V=678.5840132
```

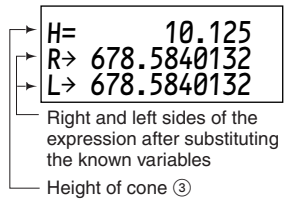
- The cursor is now on V. The value that was stored in step 9 is displayed. (volume of cone ②)

13. Press [▲] [▲] to go back to the variable H.

```
V=1r3πR²H
H=                8.
```

- This time the value of H from memory is also displayed.

14. Press [2ndF] [EXE] to find the height of cone ③.
    - Note that the calculator finds the value of the variable that the cursor is on when you press [2ndF] [EXE].
    - Now you have the height of cone ③ that has the same volume as cone ②.
    - R→ and L→ are the values computed by Newton's method, which is used to determine the accuracy of the solution.



Other features

Your calculator has a range of features that can be used to perform many calculations other than those we went through in the quick tour. Some of the important features are described below.

Statistical calculations:

You can perform one- and two- variable weighted statistical calculations, regression calculations, and normal probability calculations. Statistical results include mean, sample standard deviation, population standard deviation, sum of data, and sum of squares of data. (See Chapter 4.)

Equation solvers:

You can perform solvers of simultaneous linear equation with two/three unknowns or quadratic/cubic equation. (See Chapter 5.)

Complex number calculations:

You can perform addition, subtraction, multiplication, and division calculations. (See Chapter 6.)

Programming:

You can program your calculator to automate certain calculations. Each program can be used in either the NORMAL or NBASE program modes. (See Chapter 7.)

Chapter 2
General Information

Clearing the Entry and Memories

Operation	Entry (Display)	A-Z, θ[*1]	Local variables	Saved equations[*2] (including saved local variables)	Multi-entry recall, ANS[*3]	STAT[*4] STAT VAR[*5]
[ON/C]	○	×	×	×	×	×
Mode selection	○	×	○	×	○	×[*6]
[2ndF] [M-CLR] [0]	○	×	×	×	×	×
[2ndF] [M-CLR] [1] [DEL]	○	○	○	×	○	×
[2ndF] [M-CLR] [2] [DEL]	○	×	×	×	×	○
[2ndF] [M-CLR] [3] [DEL]	○	○	○	○	○	○
RESET switch	○	○	○	○	○	○

○: Clear ×: Retain

*1 Global variable memories.
*2 Saved equations and local variables by the filing equations function
*3 Last answer memory.
*4 Statistical data (entered data)
*5 n, $\bar{x}$, sx, σx, Σx, Σx^2, $\bar{y}$, sy, σy, Σy, Σy^2, Σxy, a, b, c, r.
*6 Will be cleared when changing between sub-modes in the STAT mode.

Note:

- To clear one variable memory of global variable and local variable memories, press [ON/C] [STO] and then choose memory.

Memory clear key

Press [2ndF] [M-CLR] to display the menu.

```
<M-CLR>
0:DISP  1:MEMORY
2:STAT  3:RESET
```

- To initialize the display mode, press [0].
  The parameters set as follows.
  - Angular unit: DEG (See page 26.)
  - Display notation: NORM1 (See page 26.)
  - N-base: DEC (See page 44.)
- To clear all variables (excluding local variables of saved equations, statistical data and STAT variables), press [1] [DEL].
- To clear statistical data and STAT variables, press [2] [DEL].
- To RESET the calculator, press [3] [DEL]. The RESET operation will erase all data stored in memory and restore the calculator's default setting.

Editing and Correcting an Equation

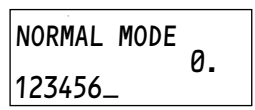
Cursor keys

Incorrect keystrokes can be changed by using the cursor keys ([◀] [▶] [▲] [▼]).

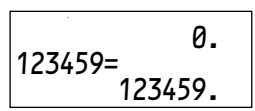
Example

Enter 123456 then correct it to 123459.

1. Press [ON/C] 123456.



2. Press [DEL] 9 [ENTER].



- If the cursor is located at the right end of an equation, the [DEL] key will function as a backspace key.
- You can return to the equation just after getting an answer by pressing the cursor keys. After returning to the equation, the following operations are useful;

  [2ndF] [◀] or [2ndF] [▶]: To jump the cursor to the beginning or the end of equation.

Overwrite mode and insert mode

- Pressing [2ndF] [INS] switches between the two editing modes: overwrite mode (default); and insert mode. A rectangular cursor indicates preexisting data will be overwritten as you make entries, while a triangular cursor indicates that an entry will be inserted at the cursor.
- In the overwrite mode, data under the cursor will be overwritten by the number you enter. To insert a number in the insert mode, move the cursor to the place immediately after where you wish to insert, then make the desired entry.
- The mode set will be retained until [2ndF] [INS] is pressed or a RESET operation is performed.

Delete key

- To delete a number/function, move the cursor to the number/function you wish to delete, then press [DEL]. If the cursor is located at the right end of an equation, the [DEL] key will function as a backspace key.

Multi-entry recall function

Previous equations can be recalled in the NORMAL, STAT or CPLX mode. Up to 160 characters of equations can be stored in memory.

When the memory is full, stored equations are deleted in the order of the oldest first.

- Pressing [2ndF] [ENTRY] will display the previous equation. Further pressing [2ndF] [ENTRY] will display preceding equations.
- You can edit the equation after recalling it.
- The multi-entry memory is cleared by the following operations: mode change, memory clear ([2ndF] [M-CLR] [1] [DEL]), RESET, N-base conversion.

Example

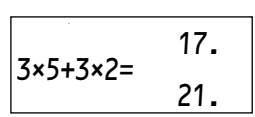
Input three expressions and then recall them.

① 3(5+2)=

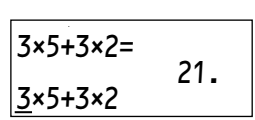
② 3×5+2=

③ 3×5+3×2=

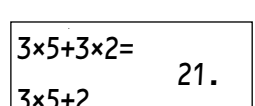
1. Press [ON/C] 3 [(] 5 [+] 2 [)] [ENTER]
   3 [×] 5 [+] 2 [ENTER]
   3 [×] 5 [+] 3 [×] 2 [ENTER]



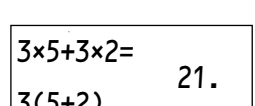
2. Press [2ndF] [ENTRY] to recall the expression ③.



3. Press [2ndF] [ENTRY] to recall the expression ②.



4. Press [2ndF] [ENTRY] to recall the expression ①.



The SET UP menu

The SET UP menu enables you to change the angular unit and the display format.

- Press [2ndF] [SET UP] to display the SET UP menu.
- Press [ON/C] to exit the SET UP menu.

Determination of the angular unit

The following three angular units (degrees, radians, and grads) can be specified.

- DEG(°) : Press [2ndF] [SET UP] [0] [0]
- RAD (rad): Press [2ndF] [SET UP] [0] [1]
- GRAD (g): Press [2ndF] [SET UP] [0] [2]

Selecting the display notation and number of decimal places

Five display notation systems are used to display calculation results: Two settings of Floating point (NORM1 and NORM2), Fixed decimal point (FIX), Scientific notation (SCI) and Engineering notation (ENG).

- When [2ndF] [SET UP] [1] [0] (FIX) or [2ndF] [SET UP] [1] [2] (ENG) is pressed, 'TAB(0-9)?' will be displayed and the number of decimal places (TAB) can be set to any value between 0 and 9.
- When [2ndF] [SET UP] [1] [1] (SCI) is pressed, 'SIG(0-9)?' will be displayed and the number of significant digits (SIG) can be set to any value between 0 and 9. Entering 0 will set a 10-digit display.
- When a floating point number does not fit in the specified range, the calculator will display the result using the scientific notation (exponential notation) system. See the next section for details.

Setting the floating point numbers system in scientific notation

The calculator has two settings for displaying a floating point number: NORM1 (default setting) and NORM2. In each display setting, a number is automatically displayed in scientific notation outside a preset range:

- NORM1: $0.000000001 \leq |x| \leq 9999999999$
- NORM2: $0.01 \leq |x| \leq 9999999999$

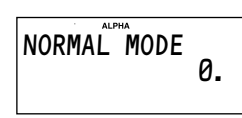
Example	Key operations	Result
100000÷3=	[ON/C] [2ndF] [SET UP] [1] [3]	
[Floating point (NORM1)]	100000 [÷] 3 [ENTER]	33333.33333
→[FIXed decimal point and TAB set to 2]	[2ndF] [SET UP] [1] [0] [2]	33333.33
→[SCIentific notation and SIG set to 3]	[2ndF] [SET UP] [1] [1] [3]	3.33×10^{04}
→[ENGineering notation and TAB set to 2]	[2ndF] [SET UP] [1] [2] [2]	33.33×10^{03}
→[Floating point (NORM1)]	[2ndF] [SET UP] [1] [3]	33333.33333
3÷1000=		
[Floating point (NORM1)]	[ON/C] 3 [÷] 1000 [ENTER]	0.003
→[Floating point (NORM2)]	[2ndF] [SET UP] [1] [4]	$3.\times10^{-03}$
→[Floating point (NORM1)]	[2ndF] [SET UP] [1] [3]	0.003

Using Memories

The calculator uses global variable memories (A–Z and θ), local variable memories (maximum of nine variables per equation), and a last answer memory used when solving equations.

Using alphabetic characters

You can enter an alphabetic character (written in blue) when ALPHA is displayed at the top of the display. To enter this mode, press [ALPHA]. To enter more than one alphabetic character, press [2ndF] [A-LOCK] to apply the alphabet-lock mode. Press [ALPHA] to escape from this mode.



Using global variables

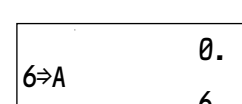
You can assign values (numbers) to global variables by pressing [STO] then A–Z and θ.

Example 1

Store 6 in global variable A.

1. Press [ON/C] 6 [STO] A.

- There is no need to press [ALPHA] because ALPHA is selected automatically when you press [STO].



Example 2

Recall global variable A.

1. Press [RCL] A.

- There is no need to press [ALPHA] because ALPHA is selected automatically when you press [RCL].

Using local variables

Nine local variables can be used in each equation or program, in addition to the global variables. Unlike global variables, the values of the local variables will be stored with the equation when you save it using the filing equations function. (See page 58.)

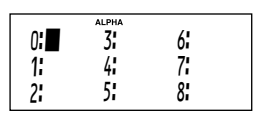
To use local variables, you first have to assign the name of the local variable using two characters: the first character must be a letter from A to Z or θ and the second must be a number from 0 to 9.

Example

Store 1.25 x 10^{-5} as local variable A_1 (in the NORMAL mode) and recall the stored number.

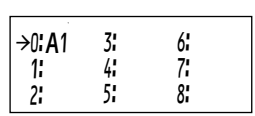
1. Press [2ndF] [VAR].

- The VAR menu appears.
- If no local variables are stored yet, ALPHA appears automatically and the calculator is ready to enter a name.



2. Press A1 [ENTER].

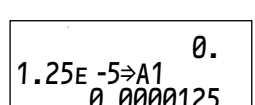
- → shows that you have finished assigning the name A_1.
- To assign more names, press [▼] to move the cursor to VAR 1 and repeat the process above.



3. Press [ON/C].

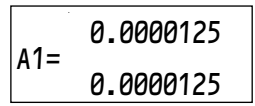
- This returns you to the previous screen.

4. Press 1.25 [Exp] [(−)] 5 [STO] [2ndF] [VAR] [0].



- You do not need to enter an alphabetic character. Just specify the named local variable using a number from 0 to 8, or move the arrow to the appropriate variable the press [ENTER].

5. Press [2ndF] [VAR] [0] [ENTER].



- The value of VAR 0 will be recalled.
- Alternatively you can recall a variable by moving the arrow to it then press [ENTER] twice.

Note:

- You can change the name of a local variable by overwriting it in the VAR menu. The cursor appears when [▶] is pressed in the VAR menu.
- Local variables not stored using the filing equations function will be deleted by mode selection or memory clear operation ([2ndF] [M-CLR] [1] [DEL]).
- Local and global variables will be cleared by creating a new program, and editing and running a program.

Using variables in an equation or a program

Both global and local variables can be used directly in an equation or a program. Local variables are useful when you need to use variables such as X_1 and X_2 at the same time in another equation. The local variable names and their values can be saved in each equation. (See page 58.)

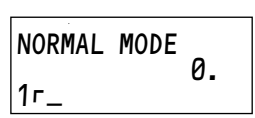
Example

Using A (6) and A_1 (0.0000125) from the last two examples, solve the expression.

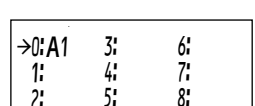
$$\frac{1}{A_1} - 1000A$$

1. Press [ON/C] 1 [a b/c].

- Start entering the expression.

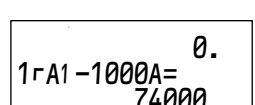


2. Press [2ndF] [VAR].



3. Press [0] [−] 1000 [ALPHA] A [ENTER].

- The display returns automatically to the previous screen after you have chosen the local variable, and you can continue to enter the expression.
- You do not need [×] if you use a variable. However, the variable must be a multiplier.

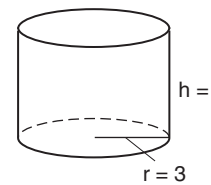


Using the last answer memory

The calculator always keeps the most recent answer in ANS memory and replaces it with the new answer every time you press an ending instruction ([ENTER], [STO] etc.). You may recall the last answer and use it in the next equation.

Example

Evaluate the base area ($S = 3^2\pi$) and volume of a cylinder ($V = 5S$) using the last answer memory.



1. Press [ON/C] 3 [x^2] [2ndF] [π] [ENTER].
   - The area of the base is now calculated.
   - The number 28.27433388 is held in ANS memory.

```
                    0.
3²π=
          28.27433388
```

2. Press [ON/C] 5 [ALPHA] [ANS] [ENTER].
   - You now have the volume of the cylinder.

```
                    0.
5Ans=
        141.3716694
```

The last answer is cleared (i.e. set to 0) if you press the RESET switch, change the mode or memory clear operation ([2ndF] [M-CLR] [1] [DEL]), but not if you turn the calculator off.

Global variable M

Using the M memory, in addition to the features of global variables, a value can be added to or subtracted from an existing memory value.

Example	Key operations	Result
	[ON/C] [STO] **M**	0.
\$150×3:Ma	150 [×] 3 [M+]	450.
+)\$250:Mb=Ma+250	250 [M+]	250.
−)Mb×5%	[RCL] **M** [×] 5 [2ndF] [%]	35.
M	[2ndF] [M−] [RCL] **M**	665.

- [M+] and [2ndF] [M−] cannot be used in the STAT mode.

Using memory in each mode

Mode	ANS	M	A-L, N-Z, θ	Local variables
NORMAL	○	○	○	○
STAT	○	○	○	○
PROG	×	○	○	○
EQN	×	×	×	×
CPLX	○	○	×	×

○: Available ×: Unavailable

Notes:

- Calculation results from the functions indicated below are automatically stored in memories replacing any existing values.
  - $\rightarrow r\theta$, $\rightarrow xy$..... R memory (r)
    θ memory (θ)
    X memory (x)
    Y memory (y)
- Use of [RCL] or [ALPHA] will recall the value stored in memory using up to 14 digits in accuracy.

Resetting the calculator

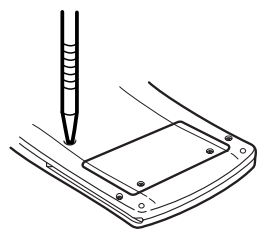
If you wish to clear all memories, variables, files and data, or if none of the keys (including [ON/C]) will function, press the RESET switch located on the back of the calculator.

In rare cases, all the keys may cease to function if the calculator is subjected to strong electrical noise or heavy shock during use. Follow the instructions below to reset the calculator.

Caution:

- **The RESET operation will erase all data stored in memory and restore the calculator's default setting.**

1. Press the RESET switch located on the back of the calculator with the tip of a ball-point pen or similar object. Do not use an object with a breakable or sharp tip.



- A display appears asking you to confirm that you really want to reset the calculator.

```
ALL DATA CL?
 YES→[DEL]
  NO→[ENTER]
```

2. Press [DEL].

- All memories, variables, files and data are cleared.

```
 ALL DATA
 CLEARED!
```

- The display goes back to the initial display in the NORMAL mode.
- The calculator will revert to the very first settings that were made when you started to use the calculator for the first time.

```
NORMAL MODE
                0.
```

Or, to cancel the operation, press [ENTER].

Note:

- When corruption of data occurs, the reset procedure may automatically be initiated upon pressing the RESET switch.
- Pressing [2ndF] [M-CLR] and [3] [DEL] can also clear all memories, variables, files and data as described above.

Chapter 3
Scientific Calculations

NORMAL mode

NORMAL mode is used for standard scientific calculations, and has the widest variety of functions. Many of the functions described in this chapter are also available for use in other modes.
Press [MODE] [0] to select the NORMAL mode.

- Differential/Integral functions, N-base functions, Solver functions and Simulation Calculation (ALGB) in this chapter are all performed in the NORMAL mode.
- In each example of this chapter, press [ON/C] to clear the display first. If the FIX, SCI or ENG indicator is displayed, clear the indicator by selecting 'NORM1' from the SET UP menu. Unless specified, set the angular unit as 'DEG'. ([2ndF] [M-CLR] [0])

Arithmetic operations

Example	Key operations	Result
$45+285\div3=$	[ON/C] 45 [+] 285 [÷] 3 [ENTER]	140.
$\frac{18+6}{15-8}=$	[(] 18 [+] 6 [)] [÷] [(] 15 [−] 8 [)] [ENTER]	3.428571429
$42\times(-5)+120=$	42 [×] [(−)] 5 [+] 120 [ENTER]	-90.
$(5\times10^{3})\div(4\times10^{-3})=$	5 [Exp] 3 [÷] 4 [Exp] [(−)] 3 [ENTER]	1250000.

Constant calculations

Example	Key operations	Result
34+57=	34 [+] 57 [ENTER]	91.
45+57=	45 [ENTER]	102.
68×25=	68 [×] 25 [ENTER]	1700.
68×40=	40 [ENTER]	2720.

- In constant calculations, the addend becomes a constant. Subtraction and division behave the same way. For multiplication, the multiplicand becomes a constant.
- In constant calculations, constants will be displayed as **K**.

Functions

Example	Key operations	Result
sin60 [°]=	[ON/C] [sin] 60 [ENTER]	0.866025403
$\cos\frac{\pi}{4}$ [rad]=	[2ndF] [SET UP] [0] [1] [cos] [2ndF] [π] [$a^{b/c}$] 4 [ENTER]	0.707106781
$\tan^{-1}1$ [g]=	[2ndF] [SET UP] [0] [2] [2ndF] [$\tan^{-1}$] 1 [ENTER] [2ndF] [M-CLR] [0]	50.

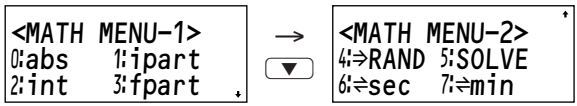
- The range of the results of inverse trigonometric functions

	$\theta = \sin^{-1}x,\ \theta = \tan^{-1}x$	$\theta = \cos^{-1}x$
DEG	$-90 \le \theta \le 90$	$0 \le \theta \le 180$
RAD	$-\frac{\pi}{2} \le \theta \le \frac{\pi}{2}$	$0 \le \theta \le \pi$
GRAD	$-100 \le \theta \le 100$	$0 \le \theta \le 200$

Example	Key operations	Result
$(\cosh 1.5 + \sinh 1.5)^2 =$	ON/C (hyp cos 1.5 + hyp sin 1.5) x^2 ENTER	20.08553692
$\tanh^{-1}\frac{5}{7} =$	2ndF arc hyp tan (5 ÷ 7) ENTER	0.895879734
$\ln 20 =$	ln 20 ENTER	2.995732274
$\log 50 =$	log 50 ENTER	1.698970004
$e^3 =$	2ndF e^x 3 ENTER	20.08553692
$10^{1.7} =$	2ndF 10^x 1.7 ENTER	50.11872336
$\frac{1}{6} + \frac{1}{7} =$	6 2ndF x^{-1} + 7 2ndF x^{-1} ENTER	0.309523809
$8^{-2} - 3^4 \times 5^2 =$	8 y^x (−) 2 − 3 y^x 4 × 5 x^2 ENTER	-2024.984375
$(12^3)^{\frac{1}{4}} =$	12 y^x 3 y^x 4 2ndF x^{-1} ENTER	6.447419591
$8^3 =$	8 x^3 ENTER	512.
$\sqrt{49} - \sqrt[4]{81} =$	2ndF $\sqrt{}$ 49 − 4 2ndF $\sqrt[x]{}$ 81 ENTER	4.
$\sqrt[3]{27} =$	2ndF $\sqrt[3]{}$ 27 ENTER	3.
$4! =$	4 2ndF n! ENTER	24.
${}_{10}P_3 =$	10 2ndF nPr 3 ENTER	720.
${}_5C_2 =$	5 2ndF nCr 2 ENTER	10.
500×25%=	500 × 25 2ndF %	125.
120÷400=?%	120 ÷ 400 2ndF %	30.
500+(500×25%)=	500 + 25 2ndF %	625.
400−(400×30%)=	400 − 30 2ndF %	280.

Math menu Functions

Other functions are available on this calculator besides the first and second functions on the key pad. These functions are accessed using the math function menu. The math menu has different contents for each mode. Press [MATH] to display the math menu. In the NORMAL mode, you can recall the following functions.



- Switch the display using [▼] [▲].
- These math menus are not available for Differential/Integral functions, N-base functions, Solver functions and Simulation Calculation (ALGB).

Function	Key operations	Result
0: abs Displays the absolute value of a number.	[MATH] [0] [(—)] 7 [ENTER]	abs -7= 7.
1: ipart Displays the integer part only of a number.	[MATH] [1] [(—)] 7.94 [ENTER]	ipart -7.94= -7.
2: int Displays the largest integer less than or equal to a number.	[MATH] [2] [(—)] 7.94 [ENTER]	int -7.94= -8.
3: fpart Displays the fractional part only of a number.	[MATH] [3] [(—)] 7.94 [ENTER]	fpart -7.94= -0.94
4: ⇒RAND Before using the Random Numbers of Random functions, designate 0.001 from 0.999 random number sequences available.	0.001 [MATH] [4]	0.001⇒RAND 0.001
The calculator can regenerate the same random numbers from the beginning. If you wish to go back to normal random numbers, press 0 [MATH] [4].	[2ndF] [RANDOM] [0] [ENTER]	random= 0.232

Function	Key operations	Result
5: SOLVE Enter the Solver function mode. (See page 52.)	[MATH] [5]	
6: ⇌sec Sexagesimal numbers are converted to seconds notation. (See page 46.)	24 [D°M'S] [MATH] [6]	24°⇌sec 86400.
7: ⇌min Sexagesimal numbers are converted to minutes notation. (See page 46.)	0 [D°M'S] 0 [D°M'S] 1500 [MATH] [7]	0°0°1500⇌min 25.

Differential/Integral Functions

Differential and integral calculations can only be performed in the NORMAL mode. It is possible to reuse the same equation over and over again and to recalculate by only changing the values without having to re-enter the equation.

- Performing a calculation will clear the value in the X memory.
- You can use both global and local variables in the equation.
- The answer calculated will be stored in the last answer memory.
- The answer calculated may include a margin of error, or an error may occur. In such a case, recalculate after changing the minute interval (dx) or subinterval (n).
- Since differential and integral calculations are performed based on the following equations, in certain rare cases correct results may not be obtained, such as when performing special calculations that contain discontinuous points.

Integral calculation (Simpson's rule):

$$S=\frac{1}{3}h\{f(a)+4\{f(a+h)+f(a+3h)+\cdots\cdots+f(a+(N-1)h)\}+2\{f(a+2h)+f(a+4h)+\cdots\cdots+f(a+(N-2)h)\}+f(b)\}\quad\left[\begin{array}{l}h=\frac{b-a}{N}\\N=2n\\a\leq x\leq b\end{array}\right]$$

Differential calculation:

$$f'(x)=\frac{f(x+\frac{dx}{2})-f(x-\frac{dx}{2})}{dx}$$

Differential function

The differential function is used as follows.

1. Press [MODE] [0] to enter the NORMAL mode.
2. Input a formula with an x variable.
3. Press [2ndF] [d/dx].
4. Input the x value and press [ENTER].
5. Input the minute interval (dx).
6. Press [ENTER] to calculate.

- To exit the differential function, press [ON/C].
- After getting the answer, press [ENTER] to return to the display for inputting the x value and the minute interval, and press [2ndF] [EXE] to recalculate at any point.

Example	Key operations	Result
$d/dx\ (x^4-0.5x^3+6x^2)$	[ON/C] [ALPHA] X* [y^x] 4 [−] 0.5 [ALPHA] X [x^3] [+] 6 [ALPHA] X [x^2] [2ndF] [d/dx]	x^4−0.5x^3+6x^2 x= dx: 0.00001
$x = 2$ $dx = 0.00002$ $d/dx = ?$	2 [ENTER] [ENTER]	x^4−0.5x^3+6x^2 d/dx= 50.
$x = 3$ $dx = 0.001$ $d/dx = ?$	[ENTER] 3 [ENTER] 0.001 [ENTER]	x^4−0.5x^3+6x^2 d/dx= 130.5000029

* X memory is specified by pressing [ALPHA] then the [3] key.

Integral function

The Integral function is used as follows.

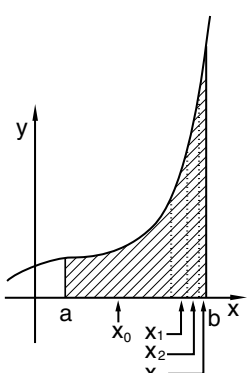
1. Press [MODE] [0] to enter the NORMAL mode.
2. Input a formula with an x variable.
3. Press [$\int dx$].
4. Input the starting value (a) of a range of integral and press [ENTER].
5. Input the finishing value (b) of a range of integral and press [ENTER].
6. Input the subinterval (n).
7. Press [ENTER] to calculate.

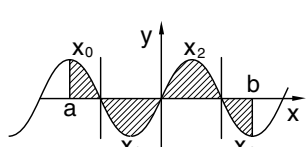
- To exit the integral function, press [ON/C].
- After getting the answer, press [ENTER] to return to the display for inputting a range of integral and subinterval, and press [2ndF] [EXE] to recalculate at any point.

Example	Key operations	Result
$\int_2^8 (x^2-5)dx$	[ON/C] [ALPHA] X [x^2] [−] 5 [$\int dx$]	a=■ 0. b= 0. n= 100.
$n = 100$ $\int dx = ?$	2 [ENTER] 8 [ENTER] [ENTER]	x^2-5 $\int dx$= 138.
$n = 10$ $\int dx = ?$	[ENTER] [ENTER] [ENTER] 10 [ENTER]	x^2-5 $\int dx$= 138.

When performing integral calculations

Integral calculations require a long calculation time, depending on the integrands and subintervals input. During calculation, 'calculating!' will be displayed. To cancel calculation, press [ON/C]. Note that there will be greater integral errors when there are large fluctuations in the integral values during minute shifting of the integral range and for periodic functions, etc., where positive and negative integral values exist depending on the interval.
For the former case, make the integral interval as small as possible. For the latter case, separate the positive and negative values.
Following these tips will provide calculations results with greater accuracy and will also shorten the calculation time.





Random Function

The Random function has four settings for the NORMAL, STAT or PROG mode. (This function is not available while using the N-base function, solver function and simulation calculations.)

Random numbers

A pseudo-random number, with three significant digits from 0 up to 0.999, can be generated by pressing [2ndF] [RANDOM] [0] [ENTER]. To generate further random numbers in succession, press [ENTER]. Press [ON/C] to exit.

- The calculator can regenerate the same random number. (See page 36.)

Random dice

To simulate a die-rolling, a random integer between 1 and 6 can be generated by pressing [2ndF] [RANDOM] [1] [ENTER]. To generate further random numbers in succession, press [ENTER]. Press [ON/C] to exit.

Random coin

To simulate a coin flip, 0 (head) or 1 (tail) can be randomly generated by pressing [2ndF] [RANDOM] [2] [ENTER]. To generate further random numbers in succession, press [ENTER]. Press [ON/C] to exit.

Random integer

An integer between 0 and 99 can be generated randomly by pressing [2ndF] [RANDOM] [3] [ENTER]. To generate further random numbers in succession, press [ENTER]. Press [ON/C] to exit.

Example	Key operations	Result
Pick a random number between 0 and 9.99.	[ON/C] [2ndF] [RANDOM] [0] [×] 10 [ENTER]	0. random×10= 6.31

- The result may not be the same each time this operation is performed.

Angular Unit Conversions

The angular unit is changed in sequence each time [2ndF] [DRG▶] ([·] key) is pressed.

Example	Key operations	Result
90°→ [rad]	[ON/C] 90 [2ndF] [DRG▶]	1.570796327
→ [g]	[2ndF] [DRG▶]	100.
→ [°]	[2ndF] [DRG▶]	90.
$\sin^{-1}0.8$ = [°]	[2ndF] [$\sin^{-1}$] 0.8 [ENTER]	53.13010235
→ [rad]	[2ndF] [DRG▶]	0.927295218
→ [g]	[2ndF] [DRG▶]	59.03344706
→ [°]	[2ndF] [DRG▶]	53.13010235

Chain Calculations

The previous calculation result can be used in a subsequent calculation. However, it cannot be recalled after entering multiple instructions.

- When using postfix functions ($\sqrt{\ }$, sin, etc.), a chain calculation is possible even if the previous calculation result is cleared by the use of the [ON/C] key.

Example	Key operations	Result
6+4=ANS	[ON/C] 6 [+] 4 [ENTER]	10.
ANS+5	[+] 5 [ENTER]	15.
8×2=ANS	8 [×] 2 [ENTER]	16.
ANS^2	[x^2] [ENTER]	256.
44+37=ANS	44 [+] 37 [ENTER]	81.
$\sqrt{ANS}$=	[2ndF] [$\sqrt{\ }$] [ENTER]	9.

Fraction Calculations

Arithmetic operations and memory calculations can be performed using fractions, and conversions between decimal numbers and fractions.

- If the number of digits to be displayed is greater than 10, the number is converted to and displayed as a decimal number.

Example	Key operations	Result
$3\frac{1}{2}+\frac{4}{3}=$ [a$\frac{b}{c}$]	[ON/C] 3 [a$^b/_c$] 1 [a$^b/_c$] 2 [+] 4 [a$^b/_c$] 3 [ENTER]	4r5r6 *
→[a.xxx]	[a$^b/_c$]	4.833333333
→[d/c]	[2ndF] [d/c]	29r6
$10^{\frac{2}{3}}=$	[2ndF] [10^x] 2 [a$^b/_c$] 3 [ENTER]	4.641588834
$\left(\frac{7}{5}\right)^5=$	7 [a$^b/_c$] 5 [y^x] 5 [ENTER]	16807r3125
$\left(\frac{1}{8}\right)^{\frac{1}{3}}=$	1 [a$^b/_c$] 8 [y^x] 1 [a$^b/_c$] 3 [ENTER]	1r2
$\sqrt{\frac{64}{225}}=$	[2ndF] [$\sqrt{\ }$] 64 [a$^b/_c$] 225 [ENTER]	8r15
$\frac{2^3}{3^4}=$	[(] 2 [y^x] 3 [)] [a$^b/_c$] [(] 3 [y^x] 4 [)] [ENTER]	8r81
$\frac{1.2}{2.3}=$	1.2 [a$^b/_c$] 2.3 [ENTER]	12r23
$\frac{1°2'3"}{2}=$	1 [D°M'S] 2 [D°M'S] 3 [a$^b/_c$] 2 [ENTER]	0°31°1.5°
$\frac{1\times10^3}{2\times10^3}=$	1 [Exp] 3 [a$^b/_c$] 2 [Exp] 3 [ENTER]	1r2
A = 7	[ON/C] 7 [STO] A	7.
$\frac{4}{A}=$	4 [a$^b/_c$] [ALPHA] A [ENTER]	4r7
$1.25+\frac{2}{5}=$ [a.xxx]	1.25 [+] 2 [a$^b/_c$] 5 [ENTER]	1.65
→[a$\frac{b}{c}$]	[a$^b/_c$]	1r13r20

* $4r5r6 = 4\frac{5}{6}$

Binary, Pental, Octal, Decimal, and Hexadecimal Operations (N-base)

This calculator can perform conversions between numbers expressed in binary, pental, octal, decimal and hexadecimal systems. It can also perform the four basic arithmetic operations, calculations with parentheses and memory calculations using binary, pental, octal, decimal, and hexadecimal numbers. Furthermore, the calculator can carry out the logical operations AND, OR, NOT, NEG, XOR and XNOR on binary, pental, octal and hexadecimal numbers.

Conversion to each system is performed by the following keys:

- 2ndF (→BIN): Converts to the binary system. 'b' appears.
- 2ndF (→PEN): Converts to the pental system. 'P' appears.
- 2ndF (→OCT): Converts to the octal system. 'O' appears.
- 2ndF (→HEX): Converts to the hexadecimal system. 'H' appears.
- 2ndF (→DEC): Converts to the decimal system. 'b', 'P', 'O' and 'H' disappear from the display.

Conversion is performed on the displayed value when these keys are pressed.

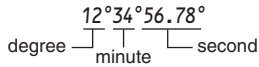
Note: Hexadecimal numbers A – F are entered into the calculator by pressing (,), (y^x), (x^2), (x^3), (log), and (ln) key respectively.

In the binary, pental, octal, and hexadecimal systems, fractional parts cannot be entered. When a decimal number having a fractional part is converted into a binary, pental, octal, or hexadecimal number, the fractional part will be truncated. Likewise, when the result of a binary, pental, octal, or hexadecimal calculation includes a fractional part, the fractional part will be truncated. In the binary, pental, octal, and hexadecimal systems, negative numbers are displayed as a complement.

Example	Key operations	Result
DEC(25)→BIN	ON/C 2ndF ►DEC 25 2ndF ►BIN	11001 b
HEX(1AC) →BIN →PEN →OCT →DEC	2ndF ►HEX 1AC 2ndF ►BIN 2ndF ►PEN 2ndF ►OCT 2ndF ►DEC	 110101100 b 3203 P 654 o 428.
BIN(1010–100) ×11 =	2ndF ►BIN (1010 − 100) × 11 ENTER	 10010 b
BIN(111)→NEG	NEG 111 ENTER	1111111001 b
HEX(1FF)+ OCT(512)= HEX(?)	2ndF ►HEX 1FF 2ndF ►OCT + 512 ENTER 2ndF ►HEX	 1511 o 349 H
2FEC– 2C9E=(A) +)2000– 1901=(B) (C)	ON/C STO M 2ndF ►HEX 2FEC − 2C9E M+ 2000 − 1901 M+ RCL M	 34E H 6FF H A4D H
1011 AND 101 = (BIN)	ON/C 2ndF ►BIN 1011 AND 101 ENTER	 1 b
5A OR C3 = (HEX)	2ndF ►HEX 5A OR C3 ENTER	DB H
NOT 10110 = (BIN)	2ndF ►BIN NOT 10110 ENTER	1111101001 b
24 XOR 4 = (OCT)	2ndF ►OCT 24 XOR 4 ENTER	20 o
B3 XNOR 2D = (HEX) →DEC	2ndF ►HEX B3 XNOR 2D ENTER 2ndF ►DEC	 FFFFFF61 H -159.

Time, Decimal and Sexagesimal Calculations

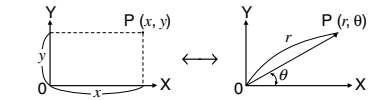
Conversion between decimal and sexagesimal numbers can be performed, and, while using sexagesimal numbers, also conversion to seconds and minutes notation. The four basic arithmetic operations and memory calculations can be performed using the sexagesimal system. Notation for sexagesimal is as follows:



Example	Key operations	Result
12°39'18.05" →[10]	ON/C 12 D°M'S 39 D°M'S 18.05 2ndF ↔DEG	12.65501389
123.678→[60]	123.678 2ndF ↔DEG	123°40°40.8°
3h30m45s + 6h45m36s = [60]	3 D°M'S 30 D°M'S 45 + 6 D°M'S 45 D°M'S 36 ENTER	10°16°21.°
1234°56'12" + 0°0'34.567" = [60]	1234 D°M'S 56 D°M'S 12 + 0 D°M'S 0 D°M'S 34.567 ENTER	1234°56°47.°
3h45m – 1.69h = [60]	3 D°M'S 45 − 1.69 ENTER 2ndF ↔DEG	2°3°36.°
sin62°12'24" = [10]	sin 62 D°M'S 12 D°M'S 24 ENTER	0.884635235
24°→["]	24 D°M'S MATH 6	86400.
1500"→[']	0 D°M'S 0 D°M'S 1500 MATH 7	25.

Coordinate Conversions

Conversions can be performed between rectangular and polar coordinates.



Rectangular coordinate Polar coordinate

- Before performing a calculation, select the angular unit.
- The calculation result is automatically stored in memories.
  - Value of r: R memory
  - Value of θ: θ memory
  - Value of x: X memory
  - Value of y: Y memory
- r and x values are stored in the last answer memory.

Example	Key operations	Result
$\begin{cases} x = 6 \\ y = 4 \end{cases} \rightarrow \begin{cases} r = \\ \theta = [°] \end{cases}$	ON/C 6 , 4 2ndF →rθ	r= 7.211102551 θ= 33.69006753
$\begin{cases} r = 14 \\ \theta = 36[°] \end{cases} \rightarrow \begin{cases} x = \\ y = \end{cases}$	14 , 36 2ndF →xy	x= 11.32623792 y= 8.228993532

Calculations Using Physical Constants

Recall a constant by pressing [2ndF] [CNST] followed by the number of the physical constant designated by a 2-digit number.
The recalled constant appears in the display mode selected with the designated number of decimal places.
Physical constants can be recalled in the NORMAL mode (when not set to binary, pental, octal, or hexadecimal), STAT mode, PROG mode and EQN mode.

Note: Physical constants are based either on the 2002 CODATA recommended values, or the 1995 Edition of the 'Guide for the Use of the International System of Units (SI)' released by NIST (National Institute of Standards and Technology), or on ISO specifications.

No.	Constant	Symbol	Unit
01	Speed of light in vacuum	c, c_0	m s^{-1}
02	Newtonian constant of gravitation	G	m^3 kg^{-1} s^{-2}
03	Standard acceleration of gravity	g_n	m s^{-2}
04	Electron mass	m_e	kg
05	Proton mass	m_p	kg
06	Neutron mass	m_n	kg
07	Muon mass	m_μ	kg
08	Atomic mass unit-kilogram relationship	lu	kg
09	Elementary charge	e	C
10	Planck constant	h	J s
11	Boltzmann constant	k	J K^{-1}
12	Magnetic constant	μ_0	N A^{-2}
13	Electric constant	ε_0	F m^{-1}
14	Classical electron radius	r_e	m
15	Fine-structure constant	α	
16	Bohr radius	a_0	m
17	Rydberg constant	R_∞	m^{-1}
18	Magnetic flux quantum	Φ_0	Wb
19	Bohr magneton	μ_B	J T^{-1}
20	Electron magnetic moment	μ_e	J T^{-1}
21	Nuclear magneton	μ_N	J T^{-1}
22	Proton magnetic moment	μ_p	J T^{-1}
23	Neutron magnetic moment	μ_n	J T^{-1}

No.	Constant	Symbol	Unit
24	Muon magnetic moment	μ_μ	J T^{-1}
25	Compton wavelength	λ_c	m
26	Proton Compton wavelength	$\lambda_{c,\,p}$	m
27	Stefan-Boltzmann constant	σ	W m^{-2} K^{-4}
28	Avogadro constant	N_A, L	mol^{-1}
29	Molar volume of ideal gas (273.15 K, 101.325 kPa)	V_m	m^3 mol^{-1}
30	Molar gas constant	R	J mol^{-1} K^{-1}
31	Faraday constant	F	C mol^{-1}
32	Von Klitzing constant	R_K	Ohm
33	Electron charge to mass quotient	$-e/m_e$	C kg^{-1}
34	Quantum of circulation	$h/2m_e$	m^2 s^{-1}
35	Proton gyromagnetic ratio	γ_p	s^{-1} T^{-1}
36	Josephson constant	K_J	Hz V^{-1}
37	Electron volt	eV	J
38	Celsius Temperature	t	K
39	Astronomical unit	AU	m
40	Parsec	pc	m
41	Molar mass of carbon-12	$M(^{12}C)$	kg mol^{-1}
42	Planck constant over 2 pi	$\hbar$	J s
43	Hartree energy	E_h	J
44	Conductance quantum	G_0	s
45	Inverse fine-structure constant	α^{-1}	
46	Proton-electron mass ratio	m_p/m_e	
47	Molar mass constant	M_u	kg mol^{-1}
48	Neutron Compton wavelength	$\lambda_{c,\,n}$	m
49	First radiation constant	c_1	W m^2
50	Second radiation constant	c_2	m K
51	Characteristic impedance of vacuum	Z_0	Ω
52	Standard atmosphere		Pa

Example	Key operations	Result
V_0 = 15.3 m/s t = 10 s $V_0 t + \frac{1}{2}gt^2$ = ? m	ON/C 15.3 × 10 + 2 2ndF x^{-1} × 2ndF CNST 03 × 10 x^2 ENTER	643.3325

Calculations Using Engineering Prefixes

Calculation can be executed in the NORMAL mode (excluding N-base), STAT mode and PROG mode using the following 12 types of prefixes.

Prefix	Operation	Unit
E (Exa)	2ndF ENG 0	10^{18}
P (Peta)	2ndF ENG 1	10^{15}
T (Tera)	2ndF ENG 2	10^{12}
G (Giga)	2ndF ENG 3	10^{9}
M (Mega)	2ndF ENG 4	10^{6}
k (kilo)	2ndF ENG 5	10^{3}
m (milli)	2ndF ENG 6	10^{-3}
μ (micro)	2ndF ENG 7	10^{-6}
n (nano)	2ndF ENG 8	10^{-9}
p (pico)	2ndF ENG 9	10^{-12}
f (femto)	2ndF ENG A	10^{-15}
a (atto)	2ndF ENG B	10^{-18}

Example	Key operations	Result
100m × 10k =	100 2ndF ENG 6 × 10 2ndF ENG 5 ENTER	1000.

Modify Function

Calculation results are internally obtained in scientific notation with up to 14 digits for the mantissa. However, since calculation results are displayed in the form designated by the display notation and the number of decimal places indicated, the internal calculation result may differ from that shown in the display. By using the modify function, the internal value is converted to match that of the display, so that the displayed value can be used without change in subsequent operations.

Example	Key operations	Result
5÷9=ANS	[ON/C] [2ndF] [SET UP] [1] [0] [1]	
ANS×9=	5 [÷] 9 [ENTER]	0.6
[FIX,TAB=1]	[×] 9 [ENTER] *1	5.0
	5 [÷] 9 [ENTER] [2ndF] [MDF]	0.6
	[×] 9 [ENTER] *2	5.4
	[2ndF] [M-CLR] [0]	

*1 $5.5555555555555 \times 10^{-1} \times 9$

*2 0.6×9

Solver Function

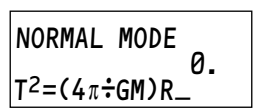
This function enables you to find any variable in an equation.

Entering and solving an equation

The solver function is used as follows.

1. Press [MODE] [0] to enter the NORMAL mode.
2. Enter both sides of an equation, using '=' and variable names.
3. Press [MATH] [5].
4. Enter the value of the known variables.
5. Move the cursor (display) to the unknown variables.
6. Press [2ndF] [EXE].

- The solver function can find any variable anywhere in an equation. It can even find variables that appear several times in an equation.

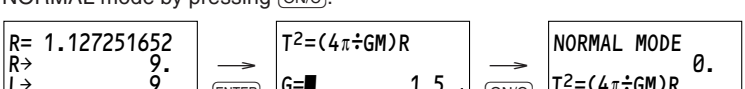


Equation entering display

- You can use both global and local variables in your equation. (See page 58.)
- Using the solver function will cause variables memory to be overwritten with new values.
- To exit the solver function, press [ON/C].

Changing the value of variables and editing an equation

When you are in the solution display, press [ENTER] to return to the display for entering values of variables, then return to the equation display in the NORMAL mode by pressing [ON/C].



Solution display

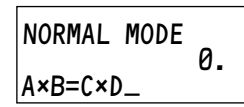
Use [▼] [▲] to move between variables.

Solving an equation

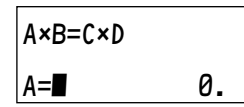
Example

Try finding the variables in the equation below.
A×B = C×D

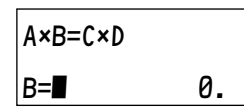
1. Press [MODE] [0] to select the NORMAL mode.
2. Press [ALPHA] A [×] [ALPHA] B [ALPHA] [=] [ALPHA] C [×] [ALPHA] D.
   - You must enter the whole equation.



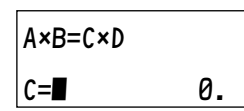
3. Press [MATH] [5].
   - The calculator automatically calls the display for entering variables and displays the variables in alphabetical order.
   - ↓ indicates that there are more variables.
   - If a variable already has a value, the calculator displays that value automatically.



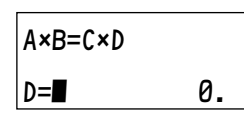
4. Press 10 [ENTER].
   - Enters a value for known variable A.
   - The cursor moves onto the next variable.



5. Press 5 [ENTER].
   - Enters a value for known variable B.



6. Press 2.5 [ENTER].
   - Enters a value for known variable C.
   - The cursor moves onto the next variable. ↑ indicates that this is the last variable.



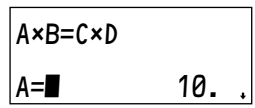
7. Press [2ndF] [EXE].
   - After showing the 'calculating!' display, the calculator finds the value for the unknown variable that was indicated by the cursor.

Values of the left-hand side of the equation

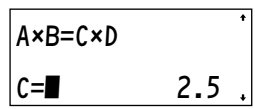
Values of the right-hand side of the equation

- The value shown on the display for the unknown variable does not have to be set to 0 to solve the equation.
- The answer is displayed on the top line and the values of the left-hand and right-hand sides of the equation appear below.

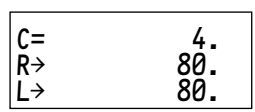
8. Press [ENTER].
- Returns you to the display for entering variables.



9. Press [▼] 8 [ENTER].
- Substitutes the value 8 for B.
- The cursor moves onto the next variable C.



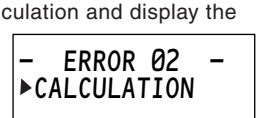
10. Press [2ndF] [EXE].
- You can find any unknowns in the same equation.



Important notes

There are several important points to remember when you use the solver function.

- To cancel calculation, press [ON/C] when 'calculating!' is displayed.
- Before entering the equation, the appropriate angular unit must be selected.
- The calculator uses Newton's method to solve equations. Due to this, there may be some equations that it fails to solve even though they are in fact solvable. (See page 123.)
- The calculator stops calculating when the values it has obtained for the left and right sides of the equation become very close. Thus in certain cases the solution it gives may not be the real answer. (See page 122.)
- In certain cases, the calculator may abort a calculation and display the message shown on the right. (See page 121.)



Simulation Calculation (ALGB)

This function enables you to find different solutions quickly using different sets of values in the same expression.

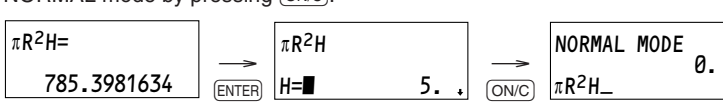
Entering an expression for simulation calculation

The simulation calculation is used as follows.

1. Press [MODE] [0] to enter the NORMAL mode.
2. Enter an expression with at least one variable.
3. Press [2ndF] [ALGB].
4. Enter the values of the variables. The calculation result will be displayed after entering the value for all used variables.
   - You can use both global and local variables in your equation, but only local variables will be stored if you save the equation. (See page 58.)
   - You need enter only the side of the equation that contains the variables.
   - Performing simulation calculation will cause the variables memories to be overwritten with new values.
   - The answer calculated will be stored in last answer memory.
   - To exit simulation calculation, press [ON/C].

Changing a value of variables and editing an expression

When you are in the solution display, press [ENTER] to return to the display for entering values of variables, then return to the equation display in the NORMAL mode by pressing [ON/C].



Solution display

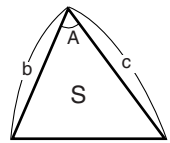
Use [▼] [▲] to move between variables.

Simulate an equation for different values

Example

Find the area S = bc sin A ÷ 2 when:

① b = 3, c = 5 and A = 90° (DEG)
② b = 3, c = 5 and A = 45° (DEG)
③ b = 4, c = 5 and A = 45° (DEG)



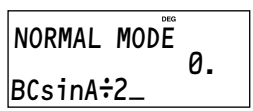
S = bc sin A ÷ 2

1. Press [MODE] [0] to select the NORMAL mode.
2. Press [2ndF] [SET UP] [0] [0] [ON/C].

- Sets the angular unit to DEG.

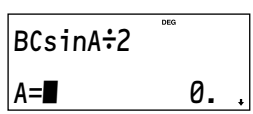
3. Press [ALPHA] B [ALPHA] C [sin] [ALPHA] A [÷] 2.

- The equation is entered in the normal way.



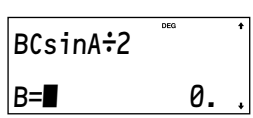
4. Press [2ndF] [ALGB].

- The calculator automatically calls the display for entering variables and picks out the variables in alphabetical order.
- If a variable already has a value, the calculator displays that value automatically.
- ↓ indicates that there are more variables.



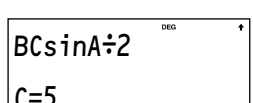
5. Press 90 [ENTER].

- The calculator picks out the next variable.

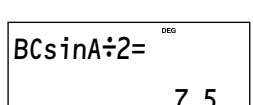


6. Press 3 [ENTER] 5.

- ↑ indicates that this is the last variable.



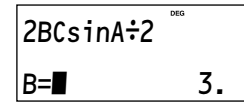
7. Press [ENTER].



Area of triangle ① is 7.5 square units.

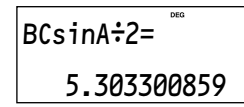
8. Press [ENTER] and then 45 [ENTER].

- After getting the answer, press [ENTER] to return to the display for entering variables.



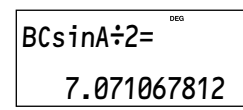
9. Press [2ndF] [EXE].

- Sides b and c are both the same length in triangle ② as in triangle ①, so you do not have to re-enter these values.



Area of triangle ② is displayed.

10. Press [ENTER] and then [▼] 4 [ENTER] [2ndF] [EXE].



Area of triangle ③ is displayed.

Filing Equations

When the calculator is in the NORMAL mode (excluding N-base), you can save equations in the EQUATION FILE. Saved equations can be loaded or deleted in the NORMAL mode.

Press [FILE] in the NORMAL mode to call the EQUATION FILE menu.

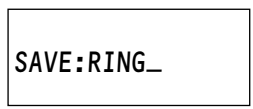
- Press [0], [1] or [2] to select if an equation is to be loaded, saved or deleted, respectively.

Saving an equation

You can save an equation as follows.

1. After entering an equation in the NORMAL mode, press [1] in the EQUATION FILE menu.
   - The file name display appears asking you to enter a title.
   - The calculator automatically locks ALPHA on to enable you to enter alphabetic characters easily. To cancel the ALPHA setting, press [ALPHA].

2. Enter the title of the file (up to seven characters).
   - If you change your mind and no longer want to save the equation, press [ON/C].



"RING" is entered as the file name.

3. Press [ENTER] to save the equation.
   - The display returns to the display before pressing [FILE].

Note:

- **When saving an equation, local variables (including their values) used in the equation are saved at the same time.**

Loading and deleting an equation

The procedures to retrieve (load) and delete an equation from memory are the same, except that you have to confirm that you wish to delete the equation.

Retrieve or delete an equation as follows.

1. Press [FILE] and then [0] or [2] to retrieve (load) or delete.

DEL has been selected.

2. Use [▼] [▲] to select the name of the file you wish to retrieve (or delete),and press [ENTER].

- The display asks for confirmation if you are deleting an equation. Press [DEL] to proceed with deletion or [ENTER] to cancel the operation.

Note:

- **If the equation being retrieved contains local variables, the local variable names and their values will be retrieved along with the equation.**
- **Any other equation on the display and local variables before the equation was retrieved are cleared.**

Chapter 4:
Statistical Calculations

The STAT mode is used to perform statistical calculations.
Press MODE 1 to select the statistics mode. The seven statistical calculations listed below can be performed. After selecting the statistics mode, select the desired sub-mode by pressing the number key that corresponds to your choice.

To change statistical sub-mode, reselect statistics mode (press MODE 1), then select the required sub-mode.

0 (SD) : Single-variable statistics

1 (LINE) : Linear regression calculation

2 (QUAD) : Quadratic regression calculation

3 (EXP) : Exponential regression calculation

4 (LOG) : Logarithmic regression calculation

5 (POWER) : Power regression calculation

6 (INV) : Inverse regression calculation

The following statistics can be obtained for each statistical calculation (refer to the table below):

	Variables	Contents	Key operations
①	n	Number of samples	MATH 0 0
	$\bar{x}$	Mean of samples (x data)	MATH 0 1
	sx	Sample standard deviation (x data)	MATH 0 2
	σx	Population standard deviation (x data)	MATH 0 3
	Σx	Sum of samples (x data)	MATH 0 4
	Σx^2	Sum of squares of samples (x data)	MATH 0 5
②	$\bar{y}$	Mean of samples (y data)	MATH 0 6
	sy	Sample standard deviation (y data)	MATH 0 7
	σy	Population standard deviation (y data)	MATH 0 8
	Σy	Sum of samples (y data)	MATH 0 9
	Σy^2	Sum of squares of samples (y data)	MATH 0 A
	Σxy	Sum of products of samples (x, y)	MATH 0 B
	a	Coefficient of regression equation	MATH 2 0
	b	Coefficient of regression equation	MATH 2 1
	c	Coefficient of quadratic regression equation	MATH 2 2
	r	Correlation coefficient	MATH 2 3

- Use MATH key to perform a STAT variable calculation.

Single-variable statistical calculation

Statistics of ① and value of the normal probability function

Linear regression calculation

Statistics of ① and ② (except coefficients c) and, in addition, estimate of y for a given x (estimate y') and estimate of x for a given y (estimate x')

Exponential regression, logarithmic regression, power regression, and inverse regression calculation

Statistics of ① and ② (except coefficients c). In addition, estimate of y for a given x (estimate y') and estimate of x for a given y (estimate x'). (Since the calculator converts each formula into a linear regression formula before actual calculation takes place, it obtains all statistics, except coefficients a and b, from converted data rather than entered data.)

Quadratic regression calculation

Statistics of ① and ② and coefficients a, b, c in the quadratic regression formula ($y = a + bx + cx^2$). (For quadratic regression calculations, no correlation coefficient (r) can be obtained.)

Data Entry and Correction

All data entered is kept in memory until STAT memory clear ([2ndF] [M-CLR] [2] [DEL]) is operated or a new STAT sub-mode is selected. Before entering new data, clear the memory contents.

Data entry

Single-variable data

Data [DATA]
Data [,] *frequency* [DATA] (To enter multiples of the same data)

Two-variable data

Data x [,] *Data* y [DATA]
Data x [,] *Data* y [,] *frequency* [DATA] (To enter multiples of the same data x and y.)

- Up to 100 data items can be entered. With single-variable data, a data item without frequency assignment is counted as one data item, while an item assigned with frequency is stored as a set of two data items. With two-variable data, a set of data items without a frequency assignment is counted as two data items, while a set of items assigned with frequency is stored as a set of three data items.

Data correction

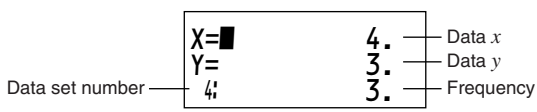
Correction prior to pressing [DATA] immediately after a data entry:
Delete incorrect data with [ON/C], then enter the correct data.

Correction after pressing [DATA]:

Use [▲] [▼] to display the data set previously entered.

Press [▼] to display the data set in ascending (oldest first) order. To reverse the display order to descending (latest first), press the [▲] key.

Each data set is displayed with 'X=', 'Y=', or 'N:' (N is the sequential number of the data set).



Display and move the cursor to the data item to be modified by using [▲] [▼], input the correct value, then press [DATA] or [ENTER].

- To delete a data set, display and move the cursor to an item of the data set to delete by using [▲] [▼], then press [2ndF] [CD]. The data set will be deleted.
- To add a new data set, press [ON/C] to exit the display of previously entered data and input the values, then press [DATA].

Example	Key operations	Result
	[MODE] [1] [0]	Stat 0 [SD] 0.
DATA 30	30 [DATA]	DATA SET= 1.
40	40 [,] 2 [DATA]	DATA SET= 2.
40		
50	50 [DATA]	DATA SET= 3.
↓		
DATA 30	[▼] [▼] [▼]	
45	45 [DATA]	X= 45.
45	3 [DATA]	2: 3.
45		
60	[▼] 60 [DATA]	X= 60.

Statistical Calculation Formulas

Type	Regression formula
Linear	$y = a + bx$
Exponential	$y = a \bullet e^{bx}$
Logarithmic	$y = a + b \bullet \ln x$
Power	$y = a \bullet x^b$
Inverse	$y = a + b\frac{1}{x}$
Quadratic	$y = a + bx + cx^2$

In the statistical calculation formulas, an error will occur if:

- The absolute value of an intermediate result or calculation result is equal to or greater than 1×10^{100}.
- The denominator is zero.
- An attempt is made to take the square root of a negative number.
- No solution exists for a quadratic regression calculation.

$$\bar{x} = \frac{\Sigma x}{n} \qquad \sigma x = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n}} \qquad sx = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n-1}}$$

$$\Sigma x = x_1 + x_2 + \cdots + x_n \qquad \Sigma x^2 = x_1^2 + x_2^2 + \cdots + x_n^2$$

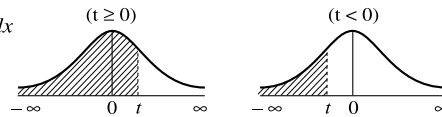
$$\bar{y} = \frac{\Sigma y}{n} \qquad \sigma y = \sqrt{\frac{\Sigma y^2 - n\bar{y}^2}{n}} \qquad sy = \sqrt{\frac{\Sigma y^2 - n\bar{y}^2}{n-1}}$$

$$\Sigma xy = x_1y_1 + x_2y_2 + \cdots + x_ny_n \qquad \Sigma y = y_1 + y_2 + \cdots + y_n \qquad \Sigma y^2 = y_1^2 + y_2^2 + \cdots + y_n^2$$

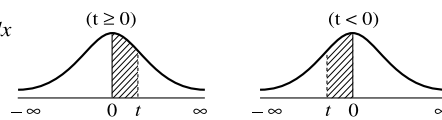
Normal Probability Calculations

- P(*t*), Q(*t*), and R(*t*) will always take positive values, even when *t*<0, because these functions follow the same principle used when solving for an area.
- Values for P(*t*), Q(*t*), and R(*t*) are given to six decimal places.

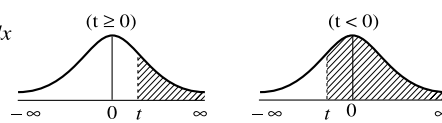
$$P(t) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{t} e^{-\frac{x^2}{2}} dx$$



$$Q(t) = \frac{1}{\sqrt{2\pi}} \int_{0}^{t} e^{-\frac{x^2}{2}} dx$$



$$R(t) = \frac{1}{\sqrt{2\pi}} \int_{t}^{\infty} e^{-\frac{x^2}{2}} dx$$



$$t = \frac{x - \bar{x}}{\sigma x}$$ Standardization conversion formula

Statistical Calculations Examples

Example	Key operations	Result
	2ndF M-CLR 2 DEL	
	MODE 1 0	Stat 0 [SD] 0.
DATA 95 80 80 75 75 75 50	95 DATA	DATA SET= 1.
	80 DATA	DATA SET= 2.
	DATA	DATA SET= 3.
	75 , 3 DATA	DATA SET= 4.
	50 DATA	DATA SET= 5.
$\bar{x}$ =	MATH 0 1 ENTER	$\bar{x}$= 75.71428571
σx =	MATH 0 3 ENTER	σx= 12.37179148
n =	MATH 0 0 ENTER	n= 7.
Σx =	MATH 0 4 ENTER	Σx= 530.
Σx^2 =	MATH 0 5 ENTER	Σx^2= 41200.
sx =	MATH 0 2 ENTER	sx= 13.3630621
sx^2 =	x^2 ENTER	178.5714286
$\frac{(95-\bar{x})}{sx} \times 10+50=$	(95 − MATH 0 1) ÷ MATH 0 2 × 10 + 50 ENTER	64.43210706
x = 60 →P(t) ?	MATH 1 1 60 MATH 1 0) ENTER	0.102012
t = −0.5 →R(t) ?	MATH 1 3 (−) 0.5) ENTER	0.691463

Example	Key operations	Result
DATA x | y 2 | 5 2 | 5 12 | 24 21 | 40 21 | 40 21 | 40 15 | 25	2ndF M-CLR 2 DEL MODE 1 1 2 , 5 DATA DATA 12 , 24 DATA 21 , 40 , 3 DATA 15 , 25 DATA	Stat 1 [LINE] 0. DATA SET= 1. DATA SET= 2. DATA SET= 3. DATA SET= 4. DATA SET= 5.
a = b = r = sx = sy =	MATH 2 0 ENTER MATH 2 1 ENTER MATH 2 3 ENTER MATH 0 2 ENTER MATH 0 7 ENTER	a= 1.050261097 b= 1.826044386 r= 0.995176343 sx=8.541216597 sy=15.67223812
x=3 → y'=? y=46 → x'=?	3 MATH 2 5 46 MATH 2 4	6.528394256 24.61590706
DATA x | y 12 | 41 8 | 13 5 | 2 23 | 200 15 | 71	2ndF M-CLR 2 DEL MODE 1 2 12 , 41 DATA 8 , 13 DATA 5 , 2 DATA 23 , 200 DATA 15 , 71 DATA	Stat 2 [QUAD] 0. DATA SET= 1. DATA SET= 2. DATA SET= 3. DATA SET= 4. DATA SET= 5.
a = b = c =	MATH 2 0 ENTER MATH 2 1 ENTER MATH 2 2 ENTER	a= 5.357506761 b=−3.120289663 c= 0.503334057
x=10 → y'=?	10 MATH 2 5	y= 24.4880159
y=22 → x'=?	22 MATH 2 4	$x1$: 9.63201409 $x2$:−3.432772026

Chapter 5
Equation Solvers

Simultaneous Linear Equations

Simultaneous linear equations with two unknowns (2-VLE) or with three unknowns (3-VLE) may be solved using this function.

① **2-VLE:** MODE 3 0

$$\begin{aligned} a_1x + b_1y &= c_1 \\ a_2x + b_2y &= c_2 \end{aligned} \qquad |D| = \begin{vmatrix} a_1 & b_1 \\ a_2 & b_2 \end{vmatrix}$$

② **3-VLE:** MODE 3 1

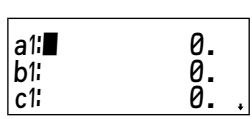
$$\begin{aligned} a_1x + b_1y + c_1z &= d_1 \\ a_2x + b_2y + c_2z &= d_2 \\ a_3x + b_3y + c_3z &= d_3 \end{aligned} \qquad |D| = \begin{vmatrix} a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \\ a_3 & b_3 & c_3 \end{vmatrix}$$

- If the determinant D = 0, an error occurs.
- If the absolute value of an intermediate result or calculation result is equal to or greater than 1×10^{100}, an error occurs.
- The results obtained by this function may include a margin of error.

Example 1

$$\begin{cases} 2x+3y = 4 \\ 5x+6y = 7 \end{cases} \Rightarrow \begin{array}{l} x = ? \\ y = ? \\ \det(D) = ? \end{array}$$

1. Press MODE 3 0 to select 2-VLE of the EQN mode.



2. Enter the value of each coefficient (a1, etc.)
   2 ENTER 3 ENTER 4 ENTER
   5 ENTER 6 ENTER 7

- Coefficients can be entered using ordinary arithmetic operations.
- To clear the entered coefficients, press ON/C.
- Press ▼ or ▲ to move line by line. Press 2ndF ▼ or 2ndF ▲ to jump to the last or top line.

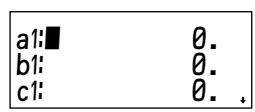
3. After inputting the last coefficient, press [ENTER] to solve the 2-VLE.

- After solving, press [ENTER] or [ON/C] to return to the coefficient entering display. You can use [2ndF] [EXE] to solve the 2-VLE, regardless of the cursor position.

Example 2

$$\begin{cases} x+y-z = 9 \\ 6x+6y-z = 17 \\ 14x-7y+2z = 42 \end{cases} \Rightarrow \begin{array}{l} x = ? \\ y = ? \\ z = ? \\ \det(D) = ? \end{array}$$

1. Press [MODE] [3] [1] to select 3-VLE of the EQN mode.

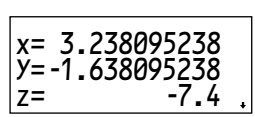


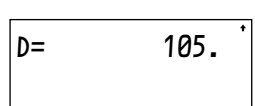
2. Enter the value of each coefficient (a1, etc.)
   1 [ENTER] 1 [ENTER] [(—)] 1 [ENTER] 9 [ENTER]
   6 [ENTER] 6 [ENTER] [(—)] 1 [ENTER] 17 [ENTER]
   14 [ENTER] [(—)] 7 [ENTER] 2 [ENTER] 42

- Coefficients can be entered using ordinary arithmetic operations.
- To clear the entered coefficients, press [ON/C].
- Press [▼] or [▲] to move line by line. Press [2ndF] [▼] or [2ndF] [▲] to jump to the last or top line.

3. After inputting the last coefficient, press [ENTER] to solve the 3-VLE.

- Press [▼] to display the det(D).
- After solving, press [ENTER] or [ON/C] to return to the coefficient entering display. You can use [2ndF] [EXE] to solve the 3-VLE, regardless of the cursor position.





Quadratic and Cubic Equation Solvers

Quadratic ($ax^2 + bx + c = 0$) or cubic ($ax^3 + bx^2 + cx + d = 0$) equations may be solved using these functions.

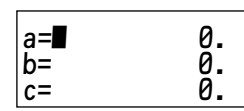
① **Quadratic equation solver (QUAD):** [MODE] [3] [2]
② **Cubic equation solver (CUBIC):** [MODE] [3] [3]

- If there are more than 2 results, the next solution can be displayed.
- The results obtained by this function may include a margin of error.

Example 1

$3x^2 + 4x - 95 = 0 \rightarrow x = ?$

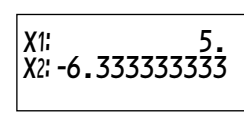
1. Press [MODE] [3] [2] to select QUAD of the EQN mode.



2. Enter the value of each coefficient (a, etc.)
   3 [ENTER] 4 [ENTER] [(—)] 95

- Coefficients can be entered using ordinary arithmetic operations.
- To clear the entered coefficients, press [ON/C].
- Press [▼] or [▲] to move line by line.

3 After inputting the last coefficient, press [ENTER] to solve the quadratic equation.



- After solving, press [ENTER] or [ON/C] to return to the coefficient entering display. You can use [2ndF] [EXE] to solve the quadratic equation, regardless of the cursor position.

Example 2

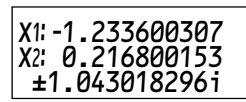
$5x^3 + 4x^2 + 3x + 7 = 0 \rightarrow x = ?$

1. Press [MODE] [3] [3] to select CUBIC of the EQN mode.

2. Enter the value of each coefficient (a, etc.)
   5 [ENTER] 4 [ENTER] 3 [ENTER] 7

- Coefficients can be entered using ordinary arithmetic operations.
- To clear the entered coefficients, press [ON/C].
- Press [▼] or [▲] to move line by line. Press [2ndF] [▼] or [2ndF] [▲] to jump to the last or top line.

3. After inputting the last coefficient, press [ENTER] to solve the cubic equation.



- After solving, press [ENTER] or [ON/C] to return to the coefficient entering display. You can use [2ndF] [EXE] to solve the cubic equation, regardless of the cursor position.

Chapter 6
Complex Number Calculations

The CPLX mode is used to carry out addition, subtraction, multiplication, and division of complex numbers. Press [MODE] [4] to select the CPLX mode.

Results of complex number calculations are expressed in two modes:

① [2ndF] [$\rightarrow xy$]: Rectangular coordinates mode (xy appears.)
② [2ndF] [$\rightarrow r\theta$]: Polar coordinates mode ($r\theta$ appears.)

Complex Number Entry

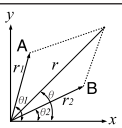
① **Rectangular coordinates are entered as follows:**
x-coordinate [+] y-coordinate [i]

or x-coordinate [+] [i] y-coordinate

② **Polar coordinates are entered as follows:**
r [$\angle$] θ

r: absolute value
θ:argument

- On selecting another mode, the imaginary part of any complex number stored in the M memory will be cleared.
- A complex number expressed in rectangular coordinates with the y-value equal to zero, or expressed in polar coordinates with the angle equal to zero, is treated as a real number.
- Press [MATH] [0] to return the complex conjugate of the specified complex number.

Example	Key operations	Result
	MODE 4	COMPLEX MODE 0.
(12–6*i*) + (7+15*i*) – (11+4*i*) =	(12 − 6 *i*) + (7 + 15 *i*) − (11 + 4 *i*) ENTER	 8. +5.i
6×(7–9*i*)× (–5+8*i*) =	6 × (7 − 9 *i*) × ((—) 5 + 8 *i*) ENTER	 222. +606.i
16×(sin30°+ *i*cos30°)÷(sin60°+ *i*cos60°)=	16 × (sin 30 + *i* cos 30) ÷ (sin 60 + *i* cos 60) ENTER	 13.85640646 +8.i
 *r*1 = 8, θ1 = 70° *r*2 = 12, θ2 = 25° ↓ *r* = ?, θ = ?°	2ndF →*r*θ 8 ∠ 70 + 12 ∠ 25 ENTER	 18.5408873 ∠42.76427608
(1 + *i*) ↓ *r* = ?, θ = ?°	2ndF →*xy* 1 + *i* ENTER 2ndF →*r*θ	1. +1.i 1.414213562 ∠45.
(2 – 3*i*)² =	2ndF →*xy* (2 − 3 *i*) x^2 ENTER	 -5. -12.i
$\frac{1}{1+i}$ =	(1 + *i*) 2ndF x^{-1} ENTER	 0.5 -0.5i
conj(5+2*i*) =	MATH 0 (5 + 2 *i*) ENTER	 5. -2.i

Chapter 7
Programming

PROG mode

A program enables you to automate a series of calculations, including those simple and complex. Programs are created either in the NORMAL program mode or in the NBASE program mode.

Entering the PROG mode

1. Press [MODE] [2] to select the PROG (PROGRAM) mode.
2. Press [0] to RUN a program, press [1] to create a NEW program, press [2] to EDIT a program, and press [3] to DELETE a program.

```
PROGRAM MODE
0:RUN   1:NEW
2:EDIT  3:DEL
```

Selecting the NORMAL program mode or the NBASE program mode

Before creating a new program ([MODE] [2] [1]), select either the NORMAL program mode or the NBASE program mode.

In the NORMAL program mode, you can perform simple mathematical calculations and statistical operations. In the NBASE program mode, you can perform logical operations and calculations using N-base numbers.

Programming concept

It is not within the scope of this manual to describe how to write programs for the calculator in detail. Previous programming experience is required to read this section. The programming language for this calculator is similar to those in general use today.

All conventional computer and calculator programs use fundamental elements such as input, flow control, loops, calculation, and output. The programming language in your calculator includes commands that allow you to incorporate all of these fundamental elements into your programs. For the command list, refer to the 'Programming Commands.' (See page 79.)

Note:

- Commands must be entered using the COMMAND menu ([COMMAND]). DO NOT type commands manually using the [ALPHA] key.

Keys and display

In the PROG mode, to make programs as simple as possible, some keys and the display may work in a different manner to other modes. The differences are described below.

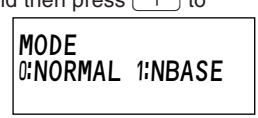
- Press [COMMAND] (the [FILE] key) to directly access the command menu for programming. The Filing Equation function does not work in PROG mode.
- While entering a program name, keys are locked in ALPHA mode (A-LOCK) automatically.
- In a program, a single line can hold up to 159 letters, where all commands are counted as a single letter. As you type in a line, the text will scroll to the left. Lines do not wrap in the PROG mode.

Creating a NEW Program

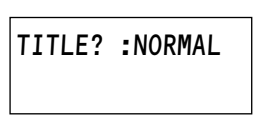
After you name the program, the calculator automatically stores the whole program under this name as you create it. You do not have to save the program manually.

Creating a NEW program

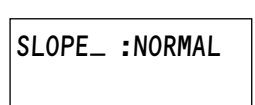
1. Press [MODE] [2] to enter the PROG mode and then press [1] to create a NEW program.
   - The display prompts you to select the NORMAL program mode or the NBASE program mode.



2. For this example, press [0] to select the NORMAL program mode.
   - The display prompts you to enter a program name.



3. Type the name of the program (i.e., SLOPE).
   - A program name can have up to 7 letters.
   - The calculator automatically switches to the alphabet-lock mode. You do not have to press the [ALPHA] key each time before entering an alphabetic character.



4. After completion, press [ENTER].
   - You are now ready to write a program.
   - Each program line is saved after you press [▲], [▼] or [ENTER].
   - You can use the calculator's regular functions as commands. You can also use the additional programming commands in the [COMMAND] menu.

Use of variables

Global and local variables are treated differently in the PROG mode.

- The letters A – Z and θ, used on their own, represent global variables. Global variables correspond to the memories of the calculator (e.g., 'C' in a program means memory C of the calculator). Global variables allow your programs to use values stored in memories, or to pass variables from one program to another. Global variables also allow you to store results from programs and use them in any mode.
- You can also name and use up to nine local variables ([2ndF] [VAR]). Local variables retain values only in an individual program.

If a line in your program contains an equation such as Y = M_1X + 5, it sets the global variable Y equal to (M_1 × X) + 5. On encountering this equation while running the program, if the value of the local variable M_1 has not been defined earlier in the program, the calculator prompts you with the display 'M_1=?' to enter a value for M_1. The global variable X will already be set to the value last stored in that memory.

```
SLOPE   :NORMAL
Y=M1 X+5
_
```

```
SLOPE   :NORMAL
M1 =?
```

With just a little practice you will soon become proficient at typing programs into your calculator.

Example

Create a simple program that requests input of the base length (B_1) and height (H_1) of a triangle and then calculates the area (A). After creating, RUN the program to determine the area of a triangle with a base of 4 units and a height of 3 units.

1. Preparing to create a NEW program

Procedure	Key operations	Display
Enter the PROG mode.	[MODE] [2]	
Select NEW.	[1]	
Select the NORMAL program mode.	[0]	
Type the program name.	AREA	
Enter the program name.	[ENTER]	AREA :NORMAL PROGRAM?

2. Entering the program

Program code	Key operations
`Print"B1=BASE`	[COMMAND] [1] [2ndF] [VAR] B1 [ENTER] [ENTER] [2ndF] [A-LOCK] [=] BASE [ALPHA] [ENTER]
`Print"H1=HEIGHT`	[COMMAND] [1] [2ndF] [VAR] [▼] H1 [ENTER] [ENTER] [2ndF] [A-LOCK] [=] HEIGHT [ALPHA] [ENTER]
`A=1r2B1H1`	[ALPHA] [A] [ALPHA] [=] 1 [a b/c] 2 [2ndF] [VAR] [ENTER] [2ndF] [VAR] [▼] [ENTER] [ENTER]
`Print"AREA`	[COMMAND] [1] [2ndF] [A-LOCK] AREA [ALPHA] [ENTER]
`Print A`	[COMMAND] [0] [ALPHA] A [ENTER]

- To enter more than one alphabetic character, press [2ndF] [A-LOCK] to apply the alphabet-lock mode. Press [ALPHA] to escape from this mode.

3. Running the program

Procedure	Key operations	Display
Return to the initial display for the PROG mode.	[ON/C]	
Select and RUN the program.	[0] (Select the program.) [ENTER]	`RUN →01:AREA`
Enter 4 for B1	4 [ENTER]	`AREA` `A=`
Enter 3 for H1	3 [ENTER]	`6.`

- If the value of a local variable you defined using [2ndF] [VAR] is unknown, the program automatically prompts you to input a value.
- To quit running the program, press [ON/C]. To run the program again, press [ENTER].
- When a program is running, text displayed by the program (using the Print" command) will wrap to the next line if the text length exceeds the display width.
- You can only enter one command per line except for special cases such as the 'If…Goto' structure.
- For more programming examples, see Chapter 8: Application Examples.

Programming Commands

In this section, all commands that are available in the PROG mode are described, excluding keyboard commands and [MATH] menu commands.

Input and display commands

1. While creating a NEW or EDIT program, press [COMMAND] to access the COMMAND menu.

- The first page of the COMMAND menu is displayed.
- Press [▼] or [▲] to scroll page by page.
- You may directly enter a command by pressing the corresponding alphanumeric key without first having to display the relevant COMMAND menu page.

Command	Key operations	Description	Examples
Print <variable>	[COMMAND] [0]	Displays the value of the specified variable. The display format is determined by the SET UP menu.	`Print A` `Print B1`
Print" <text>	[COMMAND] [1]	Displays the text entered after the quotation mark. If the text exceeds three lines, only the last three lines will be displayed.	`Print" SHARP`
Input <variable>	[COMMAND] [2]	Temporarily stops the program and prompts you to enter a value for the variable with the display '<variable>=?'.	`Input A` `Input B1`
Wait <number>	[COMMAND] [3]	Pauses the program for the specified number of seconds. The maximum wait time is 255 seconds. If no wait time is specified, the program pauses until you press any of the keys. The BUSY indicator stays on while the program is waiting.	`Wait 5` `Wait FF` (hexadecimal mode) `Wait 1010` (binary mode)

Command	Key operations	Description	Examples
Rem <text>	COMMAND 4	Indicates the line is a remark and not a command, thus allowing you to insert comments in the program. Any line beginning with Rem is ignored when running a program. Excessive use of this command will use up a considerable amount of memory.	`Rem TIME TABLE`
End	COMMAND 5	Terminates the program. If the program finishes at the last command, an End command is not required. If there is no End command in the program, the last calculated answer will be displayed when the program finishes. You can use more than one End command in the same program to terminate after different branches, subroutines, etc. have been executed.	`End`

Flow control

Command	Key operations	Description	Examples
Label <label name>	COMMAND 6	Indicates a destination point for the flow statements Goto and Gosub. Up to seven letters can be used for the label name. Each label name must be unique. You cannot use the same label name more than once in a program. Up to 20 different labels can be used in each program.	`Label LOOP1` `Label LOOP2`
Clrt	COMMAND 7	Clear the text displayed on the screen.	`Clrt`
If <condition> Goto <label name>	COMMAND 8 COMMAND 9	The If clause must be followed by a conditional statement and then a Goto command. Goto is the only command allowed to be used after the If clause. You can enter ALPHA SPACE before the Goto command to make the line easier to read.	`If B1=1 Goto LOOP1`
Goto <label name>	COMMAND 9	Causes the program to jump to the stated Label (specified by a Label command). A Goto statement must have a corresponding Label statement line that indicates where to go.	`Goto LOOP2`
Gosub <label name>	COMMAND A	Runs the subroutine beginning at the stated Label (specified by a Label command). A Gosub statement must have a corresponding subroutine that starts after the Label statement and ends with a Return command. Subroutines can be nested up to ten levels deep.	`Gosub PART1`
Return	COMMAND B	Defines the end of a subroutine. Operation returns to the command following the corresponding Gosub statement.	`Return`

Equalities and inequalities

These expressions are used to form the conditional statement in the If clause. They are the basis for looping and other flow control operation in programs.

The '=' (equals) sign is also used as a function to form a substitution command for variables.

You can also enter '=' by simply pressing [ALPHA] [=].

Symbols	Key operations	Description	Examples
=	[COMMAND] [C]	Equals. This function is also used to form a substitution command that assigns a new value to a variable, including incrementing or decrementing.	`If B=0 Goto ZERO` `A=A+1`
<	[COMMAND] [D]	Less than	`If B<0 Goto NGTV`
<=	[COMMAND] [E]	Less than or equal to.	`If B₁<=0 Goto CALC`
>=	[COMMAND] [F]	Greater than or equal to.	`If B>=0 Goto RECALC`
>	[COMMAND] [G]	Greater than	`If B₁>0 Goto PSTV`
≠	[COMMAND] [H]	Not equal to.	`If A≠B Goto DIF`

Statistical Commands

In the PROG mode, statistical commands are only available when the NORMAL program mode is selected. If the NBASE program mode is selected, the statistical command menu cannot be called.

- When you use the STAT*x* or STAT*xy* commands, the calculator erases all data previously stored in the STAT function.

Command	Key operations	Description	Examples
STAT*x*	COMMAND I	Selects single-variable statistics mode (SD).	`STATx`
STAT*xy*	COMMAND J	Selects linear regression calculation mode (LINE).	`STATxy`

Data <*x*>
Data <*x*, frequency>
Data <*x*, *y*>
Data <*x*, *y*, frequency>
	COMMAND K	Enters new statistical data. The data format must be consistent with the statistics mode selected (single-variable or linear regression). A statistical data set entered in the PROG mode cannot be accessed later for use with STAT functions.	`Data 5`
			`Data 25,2`
			`Data 72,175`
			`Data 9,96,3`

Editing a Program

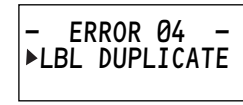
1. Press [MODE] [2] to enter the PROG mode and then press [2] to select the EDIT mode.
2. Select the program you wish to edit and press [ENTER].
   - If you want to add text into your program, press [2ndF] [INS].
   - If you want to add lines into your program, press [2ndF] [INS] (the shape of the cursor will become a triangle) and then move the cursor to the beginning of the line and press [ENTER] to add a new line there.
   - Remember that you can enter only one command per line except in the special case of the 'If…Goto' command. Do not try to enter two or more commands on a single line.
   - The line you modify is saved after you press [▲], [▼] or [ENTER]. If you do not wish to change the line, press [ON/C] twice. (The line will disappear at this point, however, the contents of the line are not deleted.)
   - To clear an entire line of a program, press [ON/C] then [▲], [▼] or [ENTER]. To delete a blank line, move the cursor to the blank line and press [DEL].
   - Any blank lines will be ignored when running.
   - [DEL] deletes the character you have just entered (the character at the cursor position).
   - You can change the name of a program by overwriting the existing name. Press [▲] to move the cursor to the title line and type the new name and press [ENTER].
3. Press [ON/C] to exit the EDIT mode.

Error Messages

The calculator displays an error message if a program encounters a problem. The error message indicates the nature of the problem while the calculator can display the line where the problem has occurred.

After entering a program, it is often necessary to debug it. To make this task easier, the calculator displays an error message if it encounters a problem while running your program.

For example, if you have more than one label with the same name in your program, you will see the message on the right.



To display the faulty line in the EDIT mode, press [▶] or [◀]. To return to the program menu, press [ON/C].

You can press [ON/C] to stop your program at any time while it is running. This will be necessary if your program enters an endless loop.

After 'BREAK!' is temporarily displayed, the initial PROG mode display will reappear. For a list of error messages, refer to the Appendix. (See page 120.)

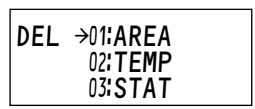
Deleting Programs

You can create as many programs as you want within the limitations of the calculator's memory. To free up space for new programs, you must delete old ones.

1. Press MODE 2 to enter the PROG mode.

2. Press 3.

- The delete window appears. All the stored programs are listed.



3. Move the cursor to the program you wish to delete and press ENTER.

- The calculator asks you if you are sure you want to delete the program.
- Press DEL to delete the program or ENTER to cancel this operation.

Chapter 8
Application Examples

Programming Examples

The following examples demonstrate the basic use of programming commands including print, input and flow controls. Use the examples for your programming reference.

Some like it hot (Celsius-Fahrenheit conversion)

This is a program to convert temperatures from Celsius to Fahrenheit and vice versa.

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.
2. Type TEMP for the program title then press [ENTER].
   - A NEW program called 'TEMP' will be created.

```
TEMP    :NORMAL
PROGRAM?
```

3. Enter the program as follows.
   - See '*' below for further explanation.

Program code	Key operations
`Label START`	[COMMAND] [6] [2ndF] [A-LOCK] START [ALPHA] [ENTER]
`Print"(1) C TO F`	[COMMAND] [1] [(] 1 [)] [2ndF] [A-LOCK] [SPACE] C [SPACE] TO [SPACE] F [ALPHA] [ENTER]
`Print"(2) F TO C`	[COMMAND] [1] [(] 2 [)] [2ndF] [A-LOCK] [SPACE] F [SPACE] TO [SPACE] C [ALPHA] [ENTER]
`Input T` * Here, the program prompts you to choose which type of conversion you wish to perform. Press [1] for "C TO F" and [2] for "F TO C".	[COMMAND] [2] [ALPHA] T [ENTER]

Program code	Key operations
`If T=1 Goto CTOF`	[COMMAND] [8] [ALPHA] T [ALPHA] [=] 1 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] CTOF [ALPHA] [ENTER]
`If T=2 Goto FTOC`	[COMMAND] [8] [ALPHA] T [ALPHA] [=] 2 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] FTOC [ALPHA] [ENTER]
`Goto START`	[COMMAND] [9] [2ndF] [A-LOCK] START [ALPHA] [ENTER]
`Label CTOF`	[COMMAND] [6] [2ndF] [A-LOCK] CTOF [ALPHA] [ENTER]
`F=(9÷5)C0+32` * The program automatically prompts you to enter a value for the local variable C_0.	[ALPHA] F [ALPHA] [=] [(] 9 [÷] 5 [)] [2ndF] [VAR] C0 [ENTER] [ENTER] [+] 32 [ENTER]
`Print F`	[COMMAND] [0] [ALPHA] F [ENTER]
`End`	[COMMAND] [5] [ENTER]
`Label FTOC`	[COMMAND] [6] [2ndF] [A-LOCK] FTOC [ALPHA] [ENTER]
`C=(5÷9)×(F0−32)` * The program automatically prompts you to enter a value for the local variable F_0.	[ALPHA] C [ALPHA] [=] [(] 5 [÷] 9 [)] [×] [(] [2ndF] [VAR] [▼] F0 [ENTER] [ENTER] [−] 32 [)] [ENTER]
`Print C`	[COMMAND] [0] [ALPHA] C [ENTER]
`End`	[COMMAND] [5] [ENTER]

Running the program

4. Press [ON/C] to return to the PROG mode menu.

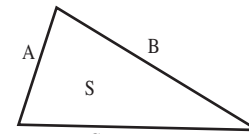
5. Press [0], select the program 'TEMP' and press [ENTER].

```
PROGRAM MODE
0:RUN    1:NEW
2:EDIT   3:DEL
```

- The program prompts you to choose which conversion you wish to perform. Then it asks you to enter the temperature value.

The Heron Formula

Obtaining the area S of triangle with side lengths of A, B and C using the Heron Formula which is true for any plane triangle.



$$S = \sqrt{T(T-A)(T-B)(T-C)}$$

$$T = \frac{A+B+C}{2}$$

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.

2. Type HERON for the program title then press [ENTER].

- A NEW program called 'HERON' will be created.

3. Enter the program as follows.

Program code	Key operations
`Label START`	[COMMAND] [6] [2ndF] [A-LOCK] START [ALPHA] [ENTER]
`Print"SIDE LENGTHS`	[COMMAND] [1] [2ndF] [A-LOCK] SIDE [SPACE] LENGTHS [ALPHA] [ENTER]
`Input A`	[COMMAND] [2] [ALPHA] A [ENTER]
`Input B`	[COMMAND] [2] [ALPHA] B [ENTER]
`Input C`	[COMMAND] [2] [ALPHA] C [ENTER]
`If (A+B)<=C Goto ERROR`	[COMMAND] [8] [(] [ALPHA] A [+] [ALPHA] B [)] [COMMAND] [E] [ALPHA] C [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] ERROR [ALPHA] [ENTER]
`If (B+C)<=A Goto ERROR`	[COMMAND] [8] [(] [ALPHA] B [+] [ALPHA] C [)] [COMMAND] [E] [ALPHA] A [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] ERROR [ALPHA] [ENTER]
`If (C+A)<=B Goto ERROR`	[COMMAND] [8] [(] [ALPHA] C [+] [ALPHA] A [)] [COMMAND] [E] [ALPHA] B [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] ERROR [ALPHA] [ENTER]
`T=(A+B+C)÷2`	[ALPHA] T [ALPHA] [=] [(] [ALPHA] A [+] [ALPHA] B [+] [ALPHA] C [)] [÷] 2 [ENTER]

Program code	Key operation
S=√(T(T−A)(T−B)(T−C))	[ALPHA] S [ALPHA] [=] [2ndF] [√] [(] [ALPHA] T [(] [ALPHA] T [−] [ALPHA] A [)] [(] [ALPHA] T [−] [ALPHA] B [)] [(] [ALPHA] T [−] [ALPHA] C [)] [)] [ENTER]
Print S	[COMMAND] [0] [ALPHA] S [ENTER]
End	[COMMAND] [5] [ENTER]
Label ERROR	[COMMAND] [6] [2ndF] [A-LOCK] ERROR [ALPHA] [ENTER]
Print"NO TRIANGLE	[COMMAND] [1] [2ndF] [A-LOCK] NO [SPACE] TRIANGLE [ALPHA] [ENTER]
Wait 1	[COMMAND] [3] 1 [ENTER]
Print"REENTER	[COMMAND] [1] [2ndF] [A-LOCK] REENTER [ALPHA] [ENTER]
Goto START	[COMMAND] [9] [2ndF] [A-LOCK] START [ALPHA] [ENTER]

Example

Obtain the area of the triangle with the side lengths of 20 cm (A), 35 cm (B) and 40 cm (C).

4. Press [ON/C] to return to the PROG mode menu.

5. Press [0], select the program 'HERON' and press [ENTER].

```
HERON  :NORMAL
SIDE LENGTHS
A=?
```

- If the values you enter do not satisfy the conditions to make a triangle (e.g. A + B > C where A, B, C are the side lengths), the program prompts you to re-enter the values from the beginning. If you wish to stop the program, press [ON/C].

6. Enter 20 for A, 35 for B and 40 for C.

Result

The area of the triangle is approximately 350 cm^2.

```
40
S=
    349.944192
```

2B or not 2B (N-base conversion)

The conversion functions and logical operations can be used in the NBASE program mode. The following is a simple program that converts a decimal number to binary, pental, octal and hexadecimal formats.

1. Press [MODE] [2] [1] [1] to open a window for creating a NEW program in the NBASE program mode.

2. Type NBASE for the title then press [ENTER].

- A NEW program called 'NBASE' will be created.

3. Enter the program as follows.

Program code	Key operations
`Print"ENTER A`	[COMMAND] [1] [2ndF] [A-LOCK] ENTER [SPACE] A [ALPHA] [ENTER]
`Print"DECIMAL NUMBER`	[COMMAND] [1] [2ndF] [A-LOCK] DECIMAL [SPACE] NUMBER [ALPHA] [ENTER]
`Input Y`	[COMMAND] [2] [ALPHA] Y [ENTER]
`Y→BIN`	[ALPHA] Y [2ndF] [→BIN] [ENTER]
`Print"BINARY`	[COMMAND] [1] [2ndF] [A-LOCK] BINARY [ALPHA] [ENTER]
`Print Y`	[COMMAND] [0] [ALPHA] Y [ENTER]
`Wait`	[COMMAND] [3] [ENTER]
`Y→PEN`	[ALPHA] Y [2ndF] [→PEN] [ENTER]
`Print"PENTAL`	[COMMAND] [1] [2ndF] [A-LOCK] PENTAL [ALPHA] [ENTER]
`Print Y`	[COMMAND] [0] [ALPHA] Y [ENTER]
`Wait`	[COMMAND] [3] [ENTER]

Program code	Key operations
`Y→OCT`	[ALPHA] Y [2ndF] [→OCT] [ENTER]
`Print"OCTAL`	[COMMAND] [1] [2ndF] [A-LOCK] OCTAL [ALPHA] [ENTER]
`Print Y`	[COMMAND] [0] [ALPHA] Y [ENTER]
`Wait`	[COMMAND] [3] [ENTER]
`Y→HEX`	[ALPHA] Y [2ndF] [→HEX] [ENTER]
`Print"HEXADECIMAL`	[COMMAND] [1] [2ndF] [A-LOCK] HEXADECIMAL [ALPHA] [ENTER]
`Print Y`	[COMMAND] [0] [ALPHA] Y [ENTER]

Running the program

4. Press [ON/C] to return to the PROG mode menu.

5. Press [0], select the program 'NBASE' and press [ENTER].

- The program prompts you to enter a decimal number and then displays it in binary format.
- Press any key to display the number in pental format, then press any key to see it in octal format, and again press any key to see it in hexadecimal format.
- Be careful when using the Wait command in NBASE program mode. Numbers followed by Wait are processed according to the current number base, binary, pental, octal, decimal or hexadecimal.
  To specify the wait time in decimal format, define a variable (e.g., T = 5) for the wait time beforehand and use it in the Wait command (i.e., Wait T).

T test

The T-test value is obtained by comparing the mean values of sample data and expected average from sample data. Using the t- distribution table, the reliability of a mean value can be evaluated.

$$t = \frac{\bar{x} - m}{\sqrt{\frac{sx^2}{n}}}$$

m = expected mean value estimated by sample data
n = the number of samples
$\bar{x}$ = actual mean value of the samples
sx = standard deviation of the samples

Example

A's SHOP sells cookies by package on which it is stated contents are 100 g. Buy 6 sample packages and check if the statement is true.

- Setting an expected mean value as 100 (m = 100 g), a t-test value is obtained. If it is larger than the expected t-value obtained from a t-distribution table (at 5% of risk rate), the estimation is wrong. (In this case, A's SHOP does not sell honestly.)

Sample	1	2	3	4	5	6
grams	102	95	107	93	110	98

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.

2. Type TTEST for the title then press [ENTER].

- A NEW program called 'TTEST' will be created.

3. Enter the program as follows.

Program code	Key operations
STATx	COMMAND I ENTER
Data 102	COMMAND K 102 ENTER
Data 95	COMMAND K 95 ENTER
Data 107	COMMAND K 107 ENTER
Data 93	COMMAND K 93 ENTER
Data 110	COMMAND K 110 ENTER
Data 98	COMMAND K 98 ENTER
Print"MEAN	COMMAND 1 2ndF A-LOCK MEAN ALPHA ENTER
Input M	COMMAND 2 ALPHA M ENTER
T=($\bar{x}$−M)÷√(s_x^2÷n)	ALPHA T ALPHA = (MATH 5 1 − ALPHA M) ÷ 2ndF √ (MATH 5 2 x^2 ÷ MATH 5 0) ENTER
Print T	COMMAND 0 ALPHA T ENTER
End	COMMAND 5 ENTER

Running the program

4. Press ON/C to return to the PROG mode menu.

5. Press 0, select the program 'TTEST' and press ENTER.

6. Enter the expected mean value '100' and press ENTER.

```
T=
  0.303058133
```

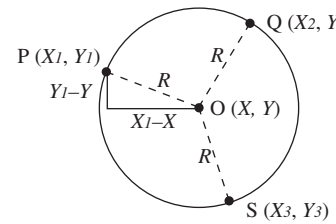
Result

The t-test value of 0.303 is smaller than the 2.571, expected mean value obtained from a t-test distribution table (at 5% of risk rate), showing that they sell honestly.

A circle that passes through 3 points

When three different points, P (X_1, Y_1), Q (X_2, Y_2), S (X_3, Y_3) are given, obtain the center coordinates O (X, Y) and the radius R of the circle that passes through these points.

To satisfy the above conditions, the distances between P, Q, S and O should be equal. as they are the radius of the same circle. Therefore,



$$PO = QO = SO = R$$

Using the Pythagorean theorem,

$$PO^2 = (X_1 - X)^2 + (Y_1 - Y)^2 = R^2$$
$$QO^2 = (X_2 - X)^2 + (Y_2 - Y)^2 = R^2$$
$$SO^2 = (X_3 - X)^2 + (Y_3 - Y)^2 = R^2$$

then

$$X = \frac{(X_1^2+Y_1^2-X_2^2-Y_2^2)(Y_2-Y_3) - (X_2^2+Y_2^2-X_3^2-Y_3^2)(Y_1-Y_2)}{2\{(X_1-X_2)(Y_2-Y_3) - (X_2-X_3)(Y_1-Y_2)\}} \quad \text{------ ①}$$

$$Y = \frac{(X_1^2+Y_1^2-X_2^2-Y_2^2)(X_2-X_3) - (X_2^2+Y_2^2-X_3^2-Y_3^2)(X_1-X_2)}{2\{(Y_1-Y_2)(X_2-X_3) - (Y_2-Y_3)(X_1-X_2)\}} \quad \text{------ ②}$$

$$R = \sqrt{(X - X_1)^2 + (Y - Y_1)^2} \quad \text{------ ③}$$

To enhance both readability and writability of the program, intermediate variables G, H, I, J, K and M are used.

The above equations reduce to

$$X = \frac{GM - HK}{2\,(IM - JK)} \qquad Y = \frac{GJ - HI}{2\,(KJ - MI)}$$

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.

2. Type CIRCLE for the title then press [ENTER].

- A NEW program called 'CIRCLE' will be created.

3. Enter the program as follows.

Program code	Key operations
`Print"ENTER COORDS`	[COMMAND] [1] [2ndF] [A-LOCK] ENTER [SPACE] COORDS [ALPHA] [ENTER]
`G=X1²+Y1²-X2²-Y2²` * Calculate intermediate values.	[ALPHA] G [ALPHA] [=] [2ndF] [VAR] X1 [ENTER] [ENTER] [x^2] [+] [2ndF] [VAR] [▼] Y1 [ENTER] [ENTER] [x^2] [−] [2ndF] [VAR] [▼] [▼] X2 [ENTER] [ENTER] [x^2] [−] [2ndF] [VAR] [▼] [▼] [▼] Y2 [ENTER] [ENTER] [x^2] [ENTER]

Program code	Key operations
H=X₂²+Y₂²−X₃²−Y₃²	[ALPHA] H [ALPHA] [=] [2ndF] [VAR] [2] [x^2] [+] [2ndF] [VAR] [3] [x^2] [−] [2ndF] [VAR] [▼] [▼] [▼] [▼] X3 [ENTER] [ENTER] [x^2] [−] [2ndF] [VAR] [▼] [▼] [▼] [▼] [▼] Y3 [ENTER] [ENTER] [x^2] [ENTER]
I=X₁−X₂	[ALPHA] I [ALPHA] [=] [2ndF] [VAR] [0] [−] [2ndF] [VAR] [2] [ENTER]
J=X₂−X₃	[ALPHA] J [ALPHA] [=] [2ndF] [VAR] [2] [−] [2ndF] [VAR] [4] [ENTER]
K=Y₁−Y₂	[ALPHA] K [ALPHA] [=] [2ndF] [VAR] [1] [−] [2ndF] [VAR] [3] [ENTER]
M=Y₂−Y₃	[ALPHA] M [ALPHA] [=] [2ndF] [VAR] [3] [−] [2ndF] [VAR] [5] [ENTER]
X=(GM−HK)÷2(IM−JK) * Perform equation ①.	[ALPHA] X [ALPHA] [=] [(] [ALPHA] G [ALPHA] M [−] [ALPHA] H [ALPHA] K [)] [÷] 2 [(] [ALPHA] I [ALPHA] M [−] [ALPHA] J [ALPHA] K [)] [ENTER]
Print X	[COMMAND] [0] [ALPHA] X [ENTER]
Wait	[COMMAND] [3] [ENTER]
Y=(GJ−HI)÷2(KJ−MI) * Perform equation ②.	[ALPHA] Y [ALPHA] [=] [(] [ALPHA] G [ALPHA] J [−] [ALPHA] H [ALPHA] I [)] [÷] 2 [(] [ALPHA] K [ALPHA] J [−] [ALPHA] M [ALPHA] I [)] [ENTER]
Print Y	[COMMAND] [0] [ALPHA] Y [ENTER]
Wait	[COMMAND] [3] [ENTER]
R=√((X−X₁)²+(Y−Y₁)²) * Perform equation ③.	[ALPHA] R [ALPHA] [=] [2ndF] [√] [(] [(] [ALPHA] X [−] [2ndF] [VAR] [0] [)] [x^2] [+] [(] [ALPHA] Y [−] [2ndF] [VAR] [1] [)] [x^2] [)] [ENTER]
Print R	[COMMAND] [0] [ALPHA] R [ENTER]

Example

Obtain the center coordinates (X, Y) and radius R of the circle that passes through points P(1, 9), Q (7, 1) and S (0, 2).

4. Press [ON/C] to return to the PROG mode menu.

5. Press [0], select the program 'CIRCLE' and press [ENTER].

6. Enter the coordinates (X_1 to X_3, Y_1 to Y_3) for the three points.

Result

The center is (4, 5) and radius is 5.

Radioactive decay

Carbon-14 (^{14}C) is a naturally occurring radioactive isotope of carbon used in the carbon dating process. Because carbon-14 decays at a steady rate, it is possible to determine the age of a once living specimen by measuring the residual amount of ^{14}C it contains.

The mass of ^{14}C contained in a sample changes according to the equation

$$M = M_0 e^{-kt} \quad \text{or} \quad t = \frac{-\ln\left(\frac{M_1}{M_0}\right)}{k}$$

where M_1 = Mass of ^{14}C at time t

M_0 = Original mass of ^{14}C

k = Radioactive decay constant (for ^{14}C, $k = 1.2118 \times 10^{-4}$ $year^{-1}$)

t = Elapsed time in years

Example

This program asks for a original mass and current mass of ^{14}C and tells you how old the specimen is. It then finds the half-life of ^{14}C.

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.

2. Type DECAY for the title then press [ENTER].

- A NEW program called 'DECAY' will be created.

```
DECAY  :NORMAL
PROGRAM?
```

3. Enter the program as follows.

Program code	Key operations
`Print"ORIGINAL MASS`	[COMMAND] [1] [2ndF] [A-LOCK] ORIGINAL [SPACE] MASS [ALPHA] [ENTER]
`Input M0`	[COMMAND] [2] [2ndF] [VAR] M0 [ENTER] [ENTER] [ENTER]
`Print"CURRENT MASS`	[COMMAND] [1] [2ndF] [A-LOCK] CURRENT [SPACE] MASS [ALPHA] [ENTER]
`Input M1`	[COMMAND] [2] [2ndF] [VAR] [▼] M1 [ENTER] [ENTER] [ENTER]

Program code	Key operations
T=−(ln(M1÷M0))÷ 1.2118E−4	[ALPHA] T [ALPHA] [=] [(−)] [(] [ln] [(] [2ndF] [VAR] [1] [÷] [2ndF] [VAR] [0] [)] [)] [÷] 1.2118 [Exp] [(−)] 4 [ENTER]
Print T	[COMMAND] [0] [ALPHA] T [ENTER]
Print"YEARS	[COMMAND] [1] [2ndF] [A-LOCK] YEARS [ALPHA] [ENTER]
End	[COMMAND] [5] [ENTER]

- The half-life of a radioactive isotope is the time required for half of its mass to decay.

Running the program

4. Press [ON/C] to return to the PROG mode menu.

5. Press [0], select the program 'DECAY' and press [ENTER].

6. Enter 100 for M_0 and 50 for M_1.

```
DECAY  :NORMAL
ORIGINAL MASS
M0 =?
```

Result

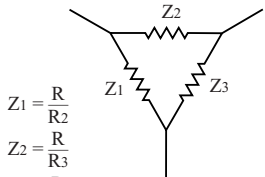
The half-life of ^{14}C is 5719.980034 years.

```
T=
   5719.980034
YEARS
```

Delta-Y impedance circuit transformation

Transformation of a Y impedance circuit to an equivalent Delta impedance circuit and vice versa.

The Delta-Y transformation is defined by the following formula:

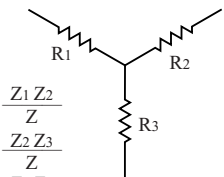


$$Z_1 = \frac{R}{R_2}$$

$$Z_2 = \frac{R}{R_3}$$

$$Z_3 = \frac{R}{R_1}$$

where $R = R_1R_2 + R_2R_3 + R_3R_1$



$$R_1 = \frac{Z_1 Z_2}{Z}$$

$$R_2 = \frac{Z_2 Z_3}{Z}$$

$$R_3 = \frac{Z_3 Z_1}{Z}$$

where $Z = Z_1 + Z_2 + Z_3$

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.

2. Type DELTAY for the title then press [ENTER].

- A NEW program called 'DELTAY' will be created.

3. Enter the program as follows.

Program code	Key operations
`Print"(1)DELTA TO Y`	[COMMAND] [1] [(] 1 [)] [2ndF] [A-LOCK] DELTA [SPACE] TO [SPACE] Y [ALPHA] [ENTER]
`Print"(2)Y TO DELTA`	[COMMAND] [1] [(] 2 [)] [2ndF] [A-LOCK] Y [SPACE] TO [SPACE] DELTA [ALPHA] [ENTER]
`Input X`	[COMMAND] [2] [ALPHA] X [ENTER]
`If X=1 Goto DTOY`	[COMMAND] [8] [ALPHA] X [ALPHA] [=] 1 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] DTOY [ALPHA] [ENTER]
`If X=2 Goto YTOD`	[COMMAND] [8] [ALPHA] X [ALPHA] [=] 2 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] YTOD [ALPHA] [ENTER]
`Label DTOY`	[COMMAND] [6] [2ndF] [A-LOCK] DTOY [ALPHA] [ENTER]

Program code	Key operations
`Z=Z1+Z2+Z3`	[ALPHA] Z [ALPHA] [=] [2ndF] [VAR] Z1 [ENTER] [ENTER] [+] [2ndF] [VAR] [▼] Z2 [ENTER] [ENTER] [+] [2ndF] [VAR] [▼] [▼] Z3 [ENTER] [ENTER] [ENTER]
`R1=Z1Z2÷Z`	[2ndF] [VAR] [▼] [▼] [▼] R1 [ENTER] [ENTER] [ALPHA] [=] [2ndF] [VAR] [0] [2ndF] [VAR] [1] [÷] [ALPHA] Z [ENTER]
`Print R1`	[COMMAND] [0] [2ndF] [VAR] [3] [ENTER]
`Wait`	[COMMAND] [3] [ENTER]
`R2=Z2Z3÷Z`	[2ndF] [VAR] [▼] [▼] [▼] [▼] R2 [ENTER] [ENTER] [ALPHA] [=] [2ndF] [VAR] [1] [2ndF] [VAR] [2] [÷] [ALPHA] Z [ENTER]
`Print R2`	[COMMAND] [0] [2ndF] [VAR] [4] [ENTER]
`Wait`	[COMMAND] [3] [ENTER]
`R3=Z3Z1÷Z`	[2ndF] [VAR] [▼] [▼] [▼] [▼] [▼] R3 [ENTER] [ENTER] [ALPHA] [=] [2ndF] [VAR] [2] [2ndF] [VAR] [0] [÷] [ALPHA] Z [ENTER]
`Print R3`	[COMMAND] [0] [2ndF] [VAR] [5] [ENTER]
`End`	[COMMAND] [5] [ENTER]
`Label YTOD`	[COMMAND] [6] [2ndF] [A-LOCK] YTOD [ALPHA] [ENTER]
`R=R1R2+R2R3+R3R1`	[ALPHA] R [ALPHA] [=] [2ndF] [VAR] [3] [2ndF] [VAR] [4] [+] [2ndF] [VAR] [4] [2ndF] [VAR] [5] [+] [2ndF] [VAR] [5] [2ndF] [VAR] [3] [ENTER]
`Z1=R÷R2`	[2ndF] [VAR] [0] [ALPHA] [=] [ALPHA] R [÷] [2ndF] [VAR] [4] [ENTER]
`Print Z1`	[COMMAND] [0] [2ndF] [VAR] [0] [ENTER]

Program code	Key operations
Wait	[COMMAND] [3] [ENTER]
Z2=R÷R3	[2ndF] [VAR] [1] [ALPHA] [=] [ALPHA] R [÷] [2ndF] [VAR] [5] [ENTER]
Print Z2	[COMMAND] [0] [2ndF] [VAR] [1] [ENTER]
Wait	[COMMAND] [3] [ENTER]
Z3=R÷R1	[2ndF] [VAR] [2] [ALPHA] [=] [ALPHA] R [÷] [2ndF] [VAR] [3] [ENTER]
Print Z3	[COMMAND] [0] [2ndF] [VAR] [2] [ENTER]
End	[COMMAND] [5] [ENTER]

Example

When the impedances Z_1, Z_2, Z_3 of a delta impedance circuit are 70, 35, 140 respectively, obtain the impedances R_1, R_2, R_3 of a Y circuit.

4. Press [ON/C] to return to the PROG mode menu.
5. Press [0], select the program 'DELTAY' and press [ENTER].

   The direction of transformation will be asked.

```
(1)DELTA TO Y
(2)Y TO DELTA
X=?
```

6. Press [1] [ENTER] to select 'DELTA TO Y' transformation.
7. Enter 70 for Z_1, 35 for Z_2 and 140 for Z_3.

Result

The impedances R_1, R_2, R_3 of the targeted Y impedance circuit are 10, 20 and 40, respectively.

Obtaining tensions of strings

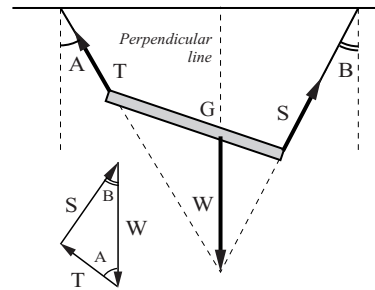
Suppose a bar is hung from the ceiling by two strings such that it balances with angles the strings make from the perpendicular lines A and B. If the weight of the bar is W, obtain the tensions in the strings S and T.

$$\frac{S}{\sin A} = \frac{T}{\sin B} = \frac{W}{\sin (A + B)}$$

$$T = W \frac{\sin B}{\sin (A + B)}$$

$$S = W \frac{\sin A}{\sin (A + B)}$$

where W: weight
T, S: tension in strings
A, B: angles that strings make from perpendicular lines (DMS)
G: gravity



1. Press MODE 2 1 0 to open a window for creating a NEW program.
2. Type TENSION for the title then press ENTER.
   - A NEW program called 'TENSION' will be created.
3. Enter the program as follows.

Program code	Key operations
`Print"ANGLES`	COMMAND 1 2ndF A-LOCK ANGLES ALPHA ENTER
`Input A`	COMMAND 2 ALPHA A ENTER
`Input B`	COMMAND 2 ALPHA B ENTER
`Print"WEIGHT`	COMMAND 1 2ndF A-LOCK WEIGHT ALPHA ENTER
`Input W`	COMMAND 2 ALPHA W ENTER
`C=A⇒DEG`	ALPHA C ALPHA = ALPHA A 2ndF ↔DEG ENTER
`D=B⇒DEG`	ALPHA D ALPHA = ALPHA B 2ndF ↔DEG ENTER

Program code	Key operations
`E=sin(C+D)`	[ALPHA] E [ALPHA] [=] [sin] [(] [ALPHA] C [+] [ALPHA] D [)] [ENTER]
`S=W × sin C÷E`	[2ndF] [A-LOCK] S [=] W [ALPHA] [×] [sin] [ALPHA] C [÷] [ALPHA] E [ENTER]
`T=W × sin D÷E`	[2ndF] [A-LOCK] T [=] W [ALPHA] [×] [sin] [ALPHA] D [÷] [ALPHA] E [ENTER]
`Print"TENSIONS`	[COMMAND] [1] [2ndF] [A-LOCK] TENSIONS [ALPHA] [ENTER]
`Print S`	[COMMAND] [0] [ALPHA] S [ENTER]
`Wait`	[COMMAND] [3] [ENTER]
`Print T`	[COMMAND] [0] [ALPHA] T [ENTER]
`End`	[COMMAND] [5] [ENTER]

Example

Calculate the tension in the strings S and T when the weight of the bar is 40 kg, angle A: 30° 15' 20" and angle B: 27° 45' 40".

4. Press [ON/C] [2ndF] [SET UP] [0] [0] to set the angular unit to DEG, then [2ndF] [SET UP] [1] [0] [3] to set display to fixed mode with the decimal point of 3 .

- In this program input angles by degree/minute/second format. They will be automatically converted to decimal degrees.

5. Press [MODE] [2] [0], select the program 'TENSION' and press [ENTER].

6. Enter 30 [D°M'S] 15 [D°M'S] 20 for angle A and press [ENTER].

7. Enter 27 [D°M'S] 45 [D°M'S] 40 for angle B and press [ENTER].

8. Enter 40 for weight W and press [ENTER] for S.

9. Press [ENTER] for T.

Results

Tension in the strings S and T are 23.761 kg and 21.966 kg, respectively.

T=	23.761
	21.966

Purchasing with payment in n-month installments

If you wish to buy goods with the price of P by n-month installments, this program determines the payment per month.

$$S = (P - D)\frac{i}{1-(1+i)^{-n}}$$

where S: payment due every month n : n-month installment
P: price of the product D: down payment
i: installment payment interest rate (%)

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.
2. Type PAYBYMN for the title then press [ENTER].
   - A NEW program called 'PAYBYMN' will be created.
3. Enter the program as follows.

Program code	Key operations
`Print"PRICE`	[COMMAND] [1] [2ndF] [A-LOCK] PRICE [ALPHA] [ENTER]
`Input P`	[COMMAND] [2] [ALPHA] P [ENTER]
`Print"DOWN PAYMENT`	[COMMAND] [1] [2ndF] [A-LOCK] DOWN [SPACE] PAYMENT [ALPHA] [ENTER]
`Input D`	[COMMAND] [2] [ALPHA] D [ENTER]
`Print"MONTHS`	[COMMAND] [1] [2ndF] [A-LOCK] MONTHS [ALPHA] [ENTER]
`Input N`	[COMMAND] [2] [ALPHA] N [ENTER]
`Print"RATE`	[COMMAND] [1] [2ndF] [A-LOCK] RATE [ALPHA] [ENTER]
`Input I`	[COMMAND] [2] [ALPHA] I [ENTER]
`I=I÷100`	[ALPHA] I [ALPHA] [=] [ALPHA] I [÷] 100 [ENTER]
`S=(P-D)×I÷(1-(1+I)^(-N))`	[ALPHA] S [ALPHA] [=] [(] [ALPHA] P [−] [ALPHA] D [)] [×] [ALPHA] I [÷] [(] 1 [−] [(] 1 [+] [ALPHA] I [)] [y^x] [(] [(−)] [ALPHA] N [)] [)] [ENTER]

Program code	Key operation
`Print S`	[COMMAND] [0] [ALPHA] S [ENTER]

Example

If you wish to buy furniture costing $3,000 with $500 as a down payment and pay the remainder in 11 month's installments with a monthly interest rate of 1%, how much is the monthly payment?

4. Press [ON/C] to return to the PROG mode menu.

5. Press [0], select the program 'PAYBYMN' and press [ENTER].

```
PAYBYMN:NORMAL
PRICE
P=?
```

6. Enter 3000 for P, 500 for D, 11 for N and 1 for I.

Result

Your monthly payment is approx. $241.

```
1
S=
   241.1351893
```

Digital dice

This program simulates rolling of multiple dice. You can play a dice game without dice or where there is not enough space to roll dice.

At the first stage, ask the number of dice to use for play. Secondly, roll dice and display the result and wait until any key is pressed.

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.

2. Type DICE for the title then press [ENTER].

- A NEW program called 'DICE' will be created.

3. Enter the program as follows.

Program code	Key operations
`Print"NO OF DICE`	[COMMAND] [1] [2ndF] [A-LOCK] NO [SPACE] OF [SPACE] DICE [ALPHA] [ENTER]
`Input N`	[COMMAND] [2] [ALPHA] N [ENTER]
`Label PLAY`	[COMMAND] [6] [2ndF] [A-LOCK] PLAY [ALPHA] [ENTER]
`M=1`	[ALPHA] M [ALPHA] [=] 1 [ENTER]
`X=0`	[ALPHA] X [ALPHA] [=] 0 [ENTER]
`Label ROLL`	[COMMAND] [6] [2ndF] [A-LOCK] ROLL [ALPHA] [ENTER]
`X=X+r.dice`	[ALPHA] X [ALPHA] [=] [ALPHA] X [+] [2ndF] [RANDOM] [1] [ENTER]
`M=M+1`	[ALPHA] M [ALPHA] [=] [ALPHA] M [+] 1 [ENTER]
`If M<=N Goto ROLL`	[COMMAND] [8] [ALPHA] M [COMMAND] [E] [ALPHA] N [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] ROLL [ALPHA] [ENTER]
`Print X`	[COMMAND] [0] [ALPHA] X [ENTER]
`Wait`	[COMMAND] [3] [ENTER]
`Goto PLAY`	[COMMAND] [9] [2ndF] [A-LOCK] PLAY [ALPHA] [ENTER]

Running the program

4. Press [ON/C] to return to the PROG mode menu.

5. Press [0], select the program 'DICE' and press [ENTER].

6. Enter the number of dice to play and press [ENTER].

7. Press [ENTER] (or any other key) to continue to play. Press [ON/C] to quit.

How many digits can you remember?

The calculator displays randomly created numbers with the number of digits (up to 9) you specified for the number of seconds you entered and asks you to enter the number you remembered. After 10 tries the score is displayed. The larger the number of digits and the shorter the seconds, the higher the score is.

1. Press [MODE] [2] [1] [0] to open a window for creating a NEW program.
2. Type NUMBER for the title then press [ENTER].
   - A NEW program called 'NUMBER' will be created.
3. Enter the program as follows.

Program code	Key operations
`M=1`	[ALPHA] M [ALPHA] [=] 1 [ENTER]
`A=0`	[ALPHA] A [ALPHA] [=] 0 [ENTER]
`Print"HOW MANY DIGITS`	[COMMAND] [1] [2ndF] [A-LOCK] HOW [SPACE] MANY [SPACE] DIGITS [ALPHA] [ENTER]
`Label NINE`	[COMMAND] [6] [2ndF] [A-LOCK] NINE [ALPHA] [ENTER]
`Print"LESS THAN 9 DIGITS`	[COMMAND] [1] [2ndF] [A-LOCK] LESS [SPACE] THAN [SPACE] [ALPHA] 9 [2ndF] [A-LOCK] [SPACE] DIGITS [ALPHA] [ENTER]
`Input N`	[COMMAND] [2] [ALPHA] N [ENTER]
`If N>9 Goto NINE`	[COMMAND] [8] [ALPHA] N [COMMAND] [G] 9 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] NINE [ALPHA] [ENTER]
`Print"HOW LONG`	[COMMAND] [1] [2ndF] [A-LOCK] HOW [SPACE] LONG [ALPHA] [ENTER]
`Input T`	[COMMAND] [2] [ALPHA] T [ENTER]
`Label QUESTION`	[COMMAND] [6] [2ndF] [A-LOCK] QUESTION [ALPHA] [ENTER]
`Label AGAIN`	[COMMAND] [6] [2ndF] [A-LOCK] AGAIN [ALPHA] [ENTER]
`S=ipart(random×10^3)`	[ALPHA] S [ALPHA] [=] [MATH] [1] [(] [2ndF] [RANDOM] [0] [×] [2ndF] [10^x] 3 [)] [ENTER]

Program code	Key operations
`If S<100 Goto AGAIN`	[COMMAND] [8] [ALPHA] S [COMMAND] [D] 100 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] AGAIN [ALPHA] [ENTER]
`S=S×10^(-3)`	[ALPHA] S [ALPHA] [=] [ALPHA] S [×] [2ndF] [10^x] [(] [(−)] 3 [)] [ENTER]
`If N>6 Goto SIX`	[COMMAND] [8] [ALPHA] N [COMMAND] [G] 6 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] SIX [ALPHA] [ENTER]
`If N>3 Goto THREE`	[COMMAND] [8] [ALPHA] N [COMMAND] [G] 3 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] THREE [ALPHA] [ENTER]
`Q=ipart(Sx10^N)`	[ALPHA] Q [ALPHA] [=] [MATH] [1] [(] [ALPHA] S [×] [2ndF] [10^x] [ALPHA] N [)] [ENTER]
`Goto DISPLAY`	[COMMAND] [9] [2ndF] [A-LOCK] DISPLAY [ALPHA] [ENTER]
`Label SIX`	[COMMAND] [6] [2ndF] [A-LOCK] SIX [ALPHA] [ENTER]
`Q=ipart(S×10^(N-6))×10^6 +random×10^6+random×10^3`	[ALPHA] Q [ALPHA] [=] [MATH] [1] [(] [ALPHA] S [×] [2ndF] [10^x] [(] [ALPHA] N [−] 6 [)] [)] [×] [2ndF] [10^x] 6 [+] [2ndF] [RANDOM] [0] [×] [2ndF] [10^x] 6 [+] [2ndF] [RANDOM] [0] [×] [2ndF] [10^x] 3 [ENTER]
`Goto DISPLAY`	[COMMAND] [9] [2ndF] [A-LOCK] DISPLAY [ALPHA] [ENTER]
`Label THREE`	[COMMAND] [6] [2ndF] [A-LOCK] THREE [ALPHA] [ENTER]
`Q=ipart(S×10^(N-3))×10^3 +random×10^3`	[ALPHA] Q [ALPHA] [=] [MATH] [1] [(] [ALPHA] S [×] [2ndF] [10^x] [(] [ALPHA] N [−] 3 [)] [)] [×] [2ndF] [10^x] 3 [+] [2ndF] [RANDOM] [0] [×] [2ndF] [10^x] 3 [ENTER]
`Label DISPLAY`	[COMMAND] [6] [2ndF] [A-LOCK] DISPLAY [ALPHA] [ENTER]
`Clrt`	[COMMAND] [7] [ENTER]
`Print Q`	[COMMAND] [0] [ALPHA] Q [ENTER]

Program code	Key operations
`Wait T`	[COMMAND] [3] [ALPHA] T [ENTER]
`Clrt`	[COMMAND] [7] [ENTER]
`Print"ANSWER`	[COMMAND] [1] [2ndF] [A-LOCK] ANSWER [ALPHA] [ENTER]
`Input X` * If answer is correct, add (30 x number of digits / number of seconds) to score.	[COMMAND] [2] [ALPHA] X [ENTER]
`If X≠Q Goto WRONG`	[COMMAND] [8] [ALPHA] X [COMMAND] [H] [ALPHA] Q [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] WRONG [ALPHA] [ENTER]
`A=A+int(10×N÷T×3)`	[ALPHA] A [ALPHA] [=] [ALPHA] A [+] [MATH] [2] [(] 10 [×] [ALPHA] N [÷] [ALPHA] T [×] 3 [)] [ENTER]
`Label WRONG`	[COMMAND] [6] [2ndF] [A-LOCK] WRONG [ALPHA] [ENTER]
`M=M+1`	[ALPHA] M [ALPHA] [=] [ALPHA] M [+] 1 [ENTER]
`If M<=10 Goto QUESTION`	[COMMAND] [8] [ALPHA] M [COMMAND] [E] 10 [ALPHA] [SPACE] [COMMAND] [9] [2ndF] [A-LOCK] QUESTION [ALPHA] [ENTER]
`Print"YOUR SCORE IS`	[COMMAND] [1] [2ndF] [A-LOCK] YOUR [SPACE] SCORE [SPACE] IS [ALPHA] [ENTER]
`Print A`	[COMMAND] [0] [ALPHA] A [ENTER]
`End`	[COMMAND] [5] [ENTER]

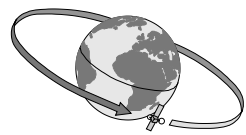
Running the program

4. Press [ON/C] to return to the PROG mode menu.
5. Press [0], select the program 'NUMBER' and press [ENTER].
6. Enter the number of digits you wish to play with N.
7. Enter the number of seconds to display the numbers.
8. Immediately after you press [ENTER], the game will start.
9. After 'ANSWER X=?' is displayed, enter the number you remembered and press [ENTER]. After 10 tries, the score is displayed.

Calculation Examples

Geosynchronous orbits

The orbit of a satellite about the Earth is geosynchronous if the period of the orbit matches the period of the Earth's rotation. At what distance from the center of the Earth can geosynchronous orbit occur?



The period of an orbit is described by the equation

$$T^2 = \frac{4\pi^2}{GM} r^3$$

where T = period of orbit
G = Gravitational constant (6.6742×10^{-11} $m^3 kg^{-1} s^{-2}$)
M = Mass of the Earth (5.976×10^{24} kg)
r = Distance between the satellite and the center of the Earth (radius of orbit)

The Earth rotates once every 23 hours, 56 minutes and 4.09 seconds. At first, convert this time into seconds.

1. Press [MODE] [0] 23 [D°M'S] 56 [D°M'S] 4.09 [D°M'S] [MATH] [6].

- Determining the value of T.

```
23°56°4.09°⇒se
c
        86164.09
```

2. Press [STO] T to store the result as global variable T.

3. Press [2ndF] [SET UP] [1] [1] [4].

- Select the scientific display format with four significant digits.
- Use the solver function to solve the equation for r.

```
        86164.09
Ans⇒T
        8.616E04
```

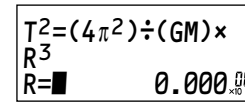
4. Press [ON/C] [ALPHA] T [x^2] [ALPHA] [=] [(] 4 [2ndF] [π] [x^2] [)] [÷] [(] [ALPHA] G [ALPHA] M [)] [×] [ALPHA] R [x^3].

```
              0.000E00
T²=(4π²)÷(GM)×
R³_
```

5. Check the equation on the display and press [MATH] [5] to enter the solver function.

```
T²=(4π²)÷(GM)×
R³
G=■           0.000E00
```

6. Press [2ndF] [CNST] 02 [ENTER] 5.976 [Exp] 24 [ENTER].

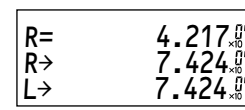


- Use the physical constants function for the G value.
- After completion of entering values for variables G and M, the cursor moves on to variable R. (The variable T has already its value.)

7. Press [2ndF] [EXE].

Result

Geosynchronous orbit is possible approximately 42,170 km (4.217×10^7 meters) from the center of the Earth.



Twinkle, twinkle, little star (Apparent magnitude of stars)

The apparent magnitude of a star is a measure of how bright it appears. It is a function of how far away the star is and the luminosity of the star.

Since stars are seen from different distances, their luminosities must be standardized before they can be compared. This is done using a quantity called the absolute magnitude, which is a measure of how bright that star would appear if it was viewed from a distance of 10 parsecs (about 32.6 light years).

If the absolute magnitude of two stars is known, the ratio of their luminosities is given by the equation.

$$\text{Log}\,\frac{L_2}{L_1} = 0.4\,(M_1 - M_2)$$

where M_1 = Absolute magnitude of the first star
M_2 = Absolute magnitude of the second star
L_1 = Luminosity of the first star
L_2 = Luminosity of the second star

Example 1

What is the ratio of the sun's luminosity to that of a star having an absolute magnitude of 2.89?
(The sun's absolute magnitude is 4.8.)

The former equation is equivalent to

$$\frac{L_2}{L_1} = 10^{0.4\,(M_1 - M_2)}$$

where $M_2 = 2.89$

1. Press [MODE] [0] and [2ndF] [M-CLR] [0].

2. Press [2ndF] [10^x] [(] 0.4 [×] [(] 4.8 [−] 2.89 [)] [)] [ENTER].

```
10^(0.4×(4.8-2.
89))=
   5.807644175
```

Result

5.807644175
The star is nearly six times as luminous as the sun.

Example 2

A second star has only 0.0003 times the luminosity of the sun. What is its absolute magnitude?

The previous equation is equivalent to

$$M_2 = M_1 - \frac{\log \frac{L_2}{L_1}}{0.4}$$

where $\frac{L_2}{L_1} = 0.0003$

1. Press 4.8 [−] [(] [log] 0.0003 [÷] 0.4 [)] [ENTER].

Result

The absolute magnitude of the second star is approximately 13.6.

```
4.8-(log0.0003
÷0.4)=
   13.60719686
```

Memory calculations

When you want to use the calculator for tasks such as adding up total sales, you can perform this type of operation using single-variable statistics.

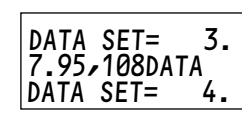
Example

In one week, an electrical store sold the items listed below at the prices and in the quantities shown. What was the total sales figure?

Item	Price	Quantity
TV set	$599.95	10
Phone	$159.95	27
Clock	$39.95	52
Calculator	$7.95	108

1. Press [MODE] [1] [0] to select the single-variable statistics mode.

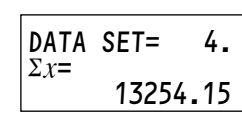
2. Press 599.95 [,] 10 [DATA], 159.95 [,] 27 [DATA], 39.95 [,] 52 [DATA] and 7.95 [,] 108 [DATA].



- All the data is entered.

3. Press [MATH] [0] [4] [ENTER].

- The calculator displays Σx, that is the total sales value.



Result

▮ Total sales were $13254.15.

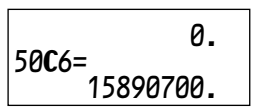
The state lottery

Example

The state you live in has two different numbers lotteries. In the first, you must pick 6 numbers between 1 and 50 in any order. In the second, you have to pick 5 numbers between 1 and 35, but you must pick them in the correct order. Which lottery gives you the better chance of winning?

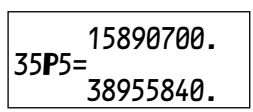
In the first lottery, your chances of winning with one ticket are one in $_{50}C_6$:

1. Press MODE 0 50 2ndF $_nC_r$ 6 ENTER.



Your chances of winning the second lottery with one ticket are one in $_{35}P_5$:

2. Press 35 2ndF $_nP_r$ 5 ENTER.



Result

▮ Your chances are better in the first lottery.

Appendix

Battery Replacement

Batteries used

- Use only the specified batteries.

Type	Model	Quantity
Lithium battery	CR2032	2

- **Be sure to write down any important data stored in the memory before replacing the batteries.**

Notes on battery replacement

Improper handling of batteries can cause electrolyte leakage or explosion. Be sure to observe the following handling rules:

- Do not mix new and old batteries.
- Make sure the new batteries are the correct type.
- When installing, orient each battery correctly as indicated in the calculator.
- Batteries are factory-installed before shipment, so may become exhausted before reaching the service life stated in the specifications.

When to replace the batteries

Replace the batteries immediately when any of the following situations occur:

- The calculator does not turn on when [ON/C] is pressed.
- The message 'Change Batteries' appears.

- **Continued use of the calculator when in low battery status may result in the memory contents being cleared.**
- **Executing programs under low battery condition may result in the memory contents being cleared.**
- **Failure to follow the battery replacement procedure as described may result in the memory contents being cleared.**

Cautions

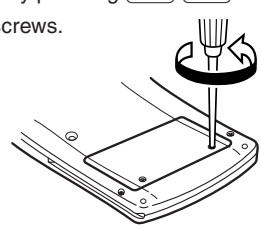
- Fluid from a leaking battery accidentally entering an eye could result in serious injury. Should this occur, wash with clean water and immediately consult a doctor.
- Should fluid from a leaking battery come in contact with your skin or clothes, immediately wash with clean water.
- If the product is not to be used for some time, to avoid damage to the unit from leaking batteries, remove them and store in a safe place.
- Do not leave exhausted batteries inside the product.
- Do not fit partially used batteries, and be sure not to mix batteries of different types.
- Keep batteries out of the reach of the children.
- Exhausted batteries left in the calculator may leak and damage the calculator.
- Explosion risk may be caused by incorrect handling.
- Do not throw batteries into a fire as they may explode.

Replacement procedure

- **All memory contents will be cleared if you remove both batteries at the same time. Always replace each battery before removing the other one.**
- Make sure the power is turned off before replacing the batteries.
- Do not press [ON/C] until the battery replacement procedure is complete.

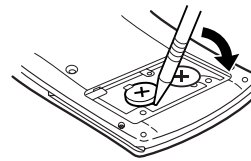
1. Turn the power off by pressing [2ndF] [OFF].

2. Remove the two screws.

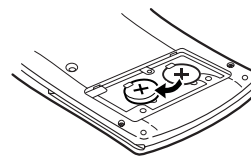


3. Lift the battery cover to remove.

4. Remove **one** used battery by prying it out with a ball-point pen or similar pointed object.
   - **Replace one battery at this step.**

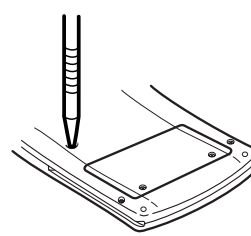


5. Install a new battery with the positive side (+) facing up.



6. Repeat steps 4 and 5 to replace the other battery.
7. Replace the cover and screws.
8. Press the RESET switch using the tip of a ball-point pen or similar object.
   - If you cannot see the message on the right, repeat steps 1–7.

```
ALL DATA CL?
 YES→[DEL]
  NO→[ENTER]
```



9. Press [ENTER].
   - **Do not press [DEL]. If [DEL] is pressed, the memory contents will be cleared.**
10. Adjust the LCD contrast. (See page 118.)

Automatic power off function

The calculator will turn itself off to save battery power if no key is pressed for approximately 10 minutes.

The OPTION menu

The OPTION menu controls display contrast, memory checking and deletion of data.

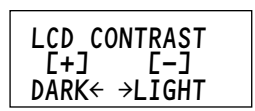
The OPTION display

Press [2ndF] [OPTION] ([(—)] key) to show the OPTION menu.

- Press [ON/C] to return to the mode in which you were working previously.

Contrast

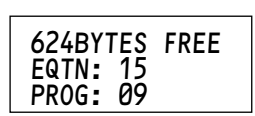
Press [0] in the OPTION menu to show the LCD CONTRAST display.



- Press [+] to darken the display and [−] to lighten it.
- It is possible to lighten the display so much that the calculator appears to be off. If the display remains blank when you press [ON], press [2ndF] [OPTION] [0] and then press [+] repeatedly to darken the display.

Memory check

Press [1] in the OPTION menu to show the MEMORY CHECK display.



- The amount of free memory in bytes is shown on the first line. When the calculator is used for the first time, the following amount of memory is available.

  [EL-5250] 4,096 bytes

  [EL-5230] 1,280 bytes
- The figures after EQTN are the numbers of equations (Filing equations functions) in the NORMAL mode.
- The figures after PROG are the numbers of programs stored in the PROG mode.

For a detailed description of how memory is used, refer to ‘Memory usage’. (See page 126.)

Deleting equation files and programs

Press [2] in the OPTION menu to show the DELETE menu.

- Press [0] or [1] to delete equation files or programs that have been stored in the NORMAL or PROG modes, respectively.

After selecting the mode for which data is to be deleted, press [DEL] to delete data. Press [ENTER] to cancel the operation.

- **Once a file has been deleted there is no way to recover it.**

To delete individual files, enter the mode that contains the data you want to delete and use the specific delete function from the menu. (See pages 59 and 86.)

If an Abnormal Condition Occurs

Should an abnormal condition occur, such as none of the keys (including [ON/C]) functioning, press the RESET switch located on the back of the calculator. Refer to page 32.

Error Messages

The following table shows common error messages and suggestions for correcting the error.

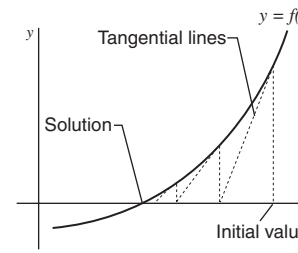
Error no.	Error message	Solution
01	SYNTAX	Verify you are using the correct syntax for the function you are trying to apply.
02	CALCULATION	Check you have not attempted to divide by zero or made some other calculation error.
03	NESTING	Use of more than the available number of buffers was attempted. (There are 10 buffers* for numeric values and 24 buffers for calculation instructions.) * 5 buffers in the CPLX mode.
04	LBL DUPLICATE	Make sure your program does not use the same label name to specify more than one location.
05	LBL UNDEFINED	Make sure your program does not have a Goto or Gosub command pointing to a label that does not exist. Note that you can include labels that are not pointed to by Goto or Gosub commands without affecting program operation.
06	LBL OVER	Make sure your program does not have more than 20 labels.
07	GOSUB STACK	Make sure your program does not have more than 10 levels of nested subroutines.
08	CAN'T RETURN	Make sure your program does not have a Return command with no corresponding Gosub command.
09	MEMORY OVER	Not enough free memory remains for what you are trying to do. Delete unneeded files and try again.
10	STORAGE FULL	Make sure the maximum number of 99 saved equations or 99 programs is not exceeded. Delete unneeded equations or programs and try again.
11	DATA OVER	Use of more than 100 data items in the STAT mode was attempted. The maximum number of 160 characters in the equation input buffer was exceeded.
(No number)	BREAK!	You have pressed [ON/C] to stop a program or solver calculation.

Using the Solver Function Effectively

The calculator uses Newton's method to solve equations. (See page 52.) Because of this, the solution it provides may differ from the true solution, or an error message may be displayed for a soluble equation. This section shows how you can obtain a more acceptable solution or make the equation soluble in such cases.

Newton's method

Newton's method is a successive approximation technique that uses tangential lines. The calculator chooses an 'approximate' solution then calculates and compares the right-hand and left-hand sides of the equation. Based on the result of this comparison, it chooses another 'approximate' solution. It repeats this process until there is hardly any discrepancy between the right-hand and left-hand sides of the equation.



Newton's method
Intersections of dotted lines with the x-axis give successive approximate solutions found using Newton's method.

'Dead end' approximations

When [2ndF] [EXE] is pressed for the first time, the calculator takes the value that is stored in memory, or zero if no value is stored, to be the initial expected value for the unknown variable and tries to solve the equation. If it fails to find an acceptable solution using this expected value, it tries again using up to nine more initial expected values until a solution is found. If none of the values lead by successive approximation toward an acceptable solution — but rather to a 'dead end' — the calculator will abort calculation and display an error message.

```
- ERROR 02 -
▶CALCULATION
```

Range of expected values

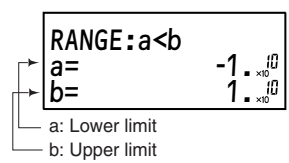
After the stored value (or zero) has been tried, new initial expected values are selected according to the range of expected values for the equation. (See 'Changing the range of expected values'.) To choose which initial expected values to try, the calculator divides the range into eight subranges of equal width and tries each of the values at the edges of these subranges in turn (starting with the lower limit of the range of expected values, a).

Calculation accuracy

- The calculator solves an equation by comparing the values of the left-hand and right-hand sides of the equation through 14-digit internal operations. If the value of the left-hand side is sufficiently close to agreeing with that of the right-hand side the calculator may present one of the 'approximate' values as a solution — even though it is not the true solution.
- The calculator will also stop trying to solve an 'approximate' solution either when it has performed more than 50 iterations using each initial expected value or when it has obtained an 'approximate' solution that is the same (to 10-digit accuracy) twice in succession.

Changing the range of expected values

After entering your equation by pressing [MATH] [5], press [2ndF] [SET UP] to adjust the range of expected values. The calculator will then prompt you for a range of expected values (between -1×10^{99} and $+1 \times 10^{99}$) to be used in the calculation.



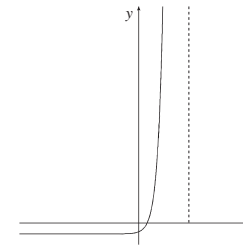
- The range of expected values returns to its default setting (-1×10^{10} to $+1 \times 10^{10}$) when the current equation is cleared or the mode is changed.

After entering the lower and upper limits (a and b) of the range of expected values, press [ON/C] to return to the previous display.

- The best solution can be found by defining the lower or upper limit (a or b) or initial value close to the expected solution.
- Having done this, press [2ndF] [EXE] several times to generate slightly different solutions. You can judge which of these is the best by comparing the values displayed for the left-hand and right-hand sides of the equation.

Equations that are difficult to solve

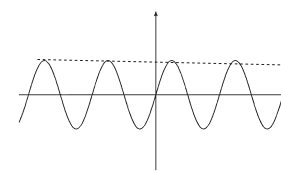
Newton's method has problems in solving certain types of equations, either because the tangential lines it uses to approximate the solutions iterate only slowly toward the correct answer, or because they do not iterate there at all. Examples of such equations include equations of which steep slopes are a feature (e.g. $y = 10^x - 5$), periodic functions (e.g. $y = \sin x$), functions featuring an inflection (e.g. $y = x^3 - 3x^2 + x + 5$) and functions where the unknown variable appears as a denominator (e.g. $y = 8/x + 1$).



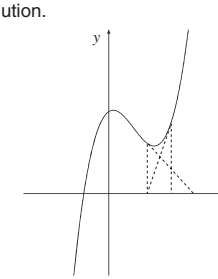
Solving $y = 10^x - 5$ for $y = 0$. Because of the steep slope, it takes a long time to iterate to the correct solution. Set limits a and b as close as possible either side of your expected solution.

Many of those equations may become soluble if a range of expected values is defined that corresponds closely to the real solution.

- For periodic functions such as sin x and cos x, the gradient near peaks or troughs is very shallow. If the initial expected value falls too close to a peak or trough, the calculator may iterate to a totally different cycle of the function and will not obtain an accurate solution. Make sure the initial expected value is an appropriate distance between a peak and a trough.
- Where appropriate, you can try rearranging the equation so that the unknown variable is no longer a denominator.



Solving $y = \sin x$ for $y = 0$.
If the Initial expected value is too close to a peak, the calculator will iterate away from the correct solution.



Solving $y = x^3 - 3x^2 + x + 5$ for $y = 0$.
If the initial expected value is $x = 3$, no solution is obtained. However, setting x to -3 gives the correct solution of -1.

Technical Data

Calculation ranges

- **Within the ranges specified, the calculator is accurate to ±1 of the least significant digit of the mantissa. However, in continuous calculations the calculation error increases due to the accumulation of each successive calculation error. (This is the same for y^x, $\sqrt[x]{\ }$, $n!$, e^x, $\ln$ etc., where continuous calculations are performed internally.)**
- **Furthermore, the calculation error will accumulate and become larger in the vicinity of inflection points and singular points of functions, and in programmed repetitive calculations.**
- Calculation ranges

$\pm 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ and 0.

If the absolute value of an entry or a final or intermediate result of a calculation is less than 10^{-99}, the value is considered to be 0 in calculations and on the display.

Function	Dynamic range
sin x, cos x, tan x	DEG: $\lvert x \rvert < 10^{10}$ (tan x : $\lvert x \rvert \neq 90$ (2n–1))* RAD: $\lvert x \rvert < \frac{\pi}{180} \times 10^{10}$ (tan x : $\lvert x \rvert \neq \frac{\pi}{2}$ (2n–1))* GRAD: $\lvert x \rvert < \frac{10}{9} \times 10^{10}$ (tan x : $\lvert x \rvert \neq 100$ (2n–1))*
$\sin^{-1}x$, $\cos^{-1}x$	$\lvert x \rvert \leq 1$
$\tan^{-1}x$, $\sqrt[3]{x}$	$\lvert x \rvert < 10^{100}$
$\ln x$, $\log x$	$10^{-99} \leq x < 10^{100}$
y^x	• $y > 0$: $-10^{100} < x \log y < 100$ • $y = 0$: $0 < x < 10^{100}$ • $y < 0$: x = n ($0 < \lvert x \rvert < 1$: $\frac{1}{x} = 2n-1$, $x \neq 0$)*, $-10^{100} < x \log \lvert y \rvert < 100$
$\sqrt[x]{y}$	• $y > 0$: $-10^{100} < \frac{1}{x} \log y < 100$ ($x \neq 0$) • $y = 0$: $0 < x < 10^{100}$ • $y < 0$: $x = 2n-1$ ($0 < \lvert x \rvert < 1 : \frac{1}{x} = n$, $x \neq 0$)*, $-10^{100} < \frac{1}{x} \log \lvert y \rvert < 100$

Function	Dynamic range
e^x	$-10^{100} < x \leq 230.2585092$
10^x	$-10^{100} < x < 100$
$\sinh x$, $\cosh x$, $\tanh x$	$\lvert x \rvert \leq 230.2585092$
$\sinh^{-1} x$	$\lvert x \rvert < 10^{50}$
$\cosh_{-1} x$	$1 \leq x < 10_{50}$
$\tanh^{-1} x$	$\lvert x \rvert < 1$
x^2	$\lvert x \rvert < 10^{50}$
x^3	$\lvert x \rvert < 2.15443469 \times 10^{33}$
$\sqrt{x}$	$0 \leq x < 10^{100}$
x^{-1}	$\lvert x \rvert < 10^{100}$ $(x \neq 0)$
n!	$0 \leq n \leq 69$*
nPr	$0 \leq r \leq n \leq 9999999999$* $\frac{n!}{(n-r)!} < 10^{100}$
nCr	$0 \leq r \leq n \leq 9999999999$* $0 \leq r \leq 69$ $\frac{n!}{(n-r)!} < 10^{100}$
↔DEG, D°M'S	0°0'0.00001" ≤ $\lvert x \rvert$ < 10000°
$x, y \rightarrow r, \theta$	$\sqrt{x^2 + y^2} < 10^{100}$
$r, \theta \rightarrow x, y$	$0 \leq r < 10^{100}$ DEG: $\lvert \theta \rvert < 10^{10}$ RAD: $\lvert \theta \rvert < \frac{\pi}{180} \times 10^{10}$ GRAD : $\lvert \theta \rvert < \frac{10}{9} \times 10^{10}$
DRG ▶	DEG→RAD, GRAD→DEG: $\lvert x \rvert < 10^{100}$ RAD→GRAD: $\lvert x \rvert < \frac{\pi}{2} \times 10^{98}$
(A+Bi)+(C+Di)	$\lvert A + C \rvert < 10^{100}$, $\lvert B + D \rvert < 10^{100}$
(A+Bi)–(C+Di)	$\lvert A - C \rvert < 10^{100}$, $\lvert B - D \rvert < 10^{100}$
(A+Bi)×(C+Di)	$(AC - BD) < 10^{100}$ $(AD + BC) < 10^{100}$
(A+Bi)÷(C+Di)	$\frac{AC + BD}{C^2 + D^2} < 10^{100}$ $\frac{BC - AD}{C^2 + D^2} < 10^{100}$ $C^2 + D^2 \neq 0$

Function	Dynamic range
→DEC →BIN →PEN →OCT →HEX AND OR XOR XNOR	DEC : $\lvert x \rvert \leq 9999999999$ BIN : $1000000000 \leq x \leq 1111111111$ $0 \leq x \leq 111111111$ PEN : $2222222223 \leq x \leq 4444444444$ $0 \leq x \leq 2222222222$ OCT : $4000000000 \leq x \leq 7777777777$ $0 \leq x \leq 3777777777$ HEX : FDABF41C01 $\leq x \leq$ FFFFFFFFFF $0 \leq x \leq$ 2540BE3FF
NOT	BIN : $1000000000 \leq x \leq 1111111111$ $0 \leq x \leq 111111111$ PEN : $2222222223 \leq x \leq 4444444444$ $0 \leq x \leq 2222222221$ OCT : $4000000000 \leq x \leq 7777777777$ $0 \leq x \leq 3777777777$ HEX : FDABF41C01 $\leq x \leq$ FFFFFFFFFF $0 \leq x \leq$ 2540BE3FE
NEG	BIN : $1000000001 \leq x \leq 1111111111$ $0 \leq x \leq 111111111$ PEN : $2222222223 \leq x \leq 4444444444$ $0 \leq x \leq 2222222222$ OCT : $4000000001 \leq x \leq 7777777777$ $0 \leq x \leq 3777777777$ HEX : FDABF41C01 $\leq x \leq$ FFFFFFFFFF $0 \leq x \leq$ 2540BE3FF

* n, r: integer

Memory usage

The amounts of memory the calculator uses for variables, programs and equations are shown below.

Variables

Each variable uses 1 byte, and each local variable uses 9 bytes to store its value.

Programs

Creating a new program uses 32 bytes of memory irrespective of the length of its name.

Each line in a program uses 3 bytes plus the number of characters or commands on the line (each character or command uses 1 byte). For example, the two lines of the program shown below use 60 bytes.

	Management	Characters, commands and variables	For value of local variables	Total
Program title	32 bytes	—	—	32 bytes
`If A=0 Goto ABC`	3 bytes	8 bytes	—	11 bytes
`A1 =A+1`	3 bytes	5 bytes	9 bytes	17 bytes
Total consumption	38 bytes	13 bytes	9 bytes	60 bytes

Filing Equation functions
Each stored equation uses 30 bytes plus the number of characters or commands.

Priority levels in calculations

Operations are performed according to the following priority:

① Fractions (1⌟4, etc.)

② ∠ , engineering prefixes

③ Functions preceded by their argument (x^{-1}, x^2, n!, etc.)

④ Y^x, $\sqrt[x]{\ }$

⑤ Implied multiplication of a memory value (2Y, etc.)

⑥ Functions followed by their argument (sin, cos, (–), etc.)

⑦ Implied multiplication of a function (2sin30, etc.)

⑧ nCr, nPr

⑨ ×, ÷

⑩ +, –

⑪ AND

⑫ OR, XOR, XNOR

⑬ =, M+, M–, ⇒M, ▶DEG, ▶RAD, ▶GRAD, DATA, CD, →rθ, →xy, and other calculation ending instructions

- If parentheses are used, the parenthesized calculations have precedence over the other calculations.

Specifications

Model:	EL-5230/5250
Display type:	[14 characters and 2 exponents] × 3 rows
Dot matrix characters:	5 × 7 dots /character
Number of display digits:	10-digit mantissa + 2-digit exponent
Input ranges:	$\pm 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ and 0. (up to 10-digit mantissa)
Number of internal calculation digits:	14-digit mantissa
Pending operations:	24 calculations 10 numeric values (5 numeric values in the CPLX modes)
Calculation functions:	Calculations (four basic arithmetic operations, calculations with parentheses, memory calculations, function calculations, etc.), differential/integral functions, binary/pental/octal/decimal/hexadecimal operations, solver functions, simulation calculations, complex number calculations, etc.
Statistical calculations:	One-variable statistics, two-variable statistics, normal probability calculations, etc.
Equation solvers:	Simultaneous linear equations, and quadratic/cubic equation solvers.
Programming function:	New programming, running a program, and editing a program and deleting a program.
Option menu:	LCD contrast, memory check and data deletion
Memory capacity:	[EL-5250] 4,096 bytes (user area) [EL-5230] 1,280 bytes (user area)
Power source:	3 V ⎓ (DC): Lithium battery (CR 2032) × 2
Auto power off:	After approximately 10 minutes
Power consumption:	0.002 W
Operating temperature:	0°C – 40°C (32°F – 104°F)
Operating time:	Approximately 1,800 hours* (at 25°C (77°F), assuming each hour consists of 5 minutes of continuous operation and 55 minutes of display time).

Dimensions:	79.6 mm (W) × 154.5 mm (D) × 15.2 mm (H) 3-1/8" (W) × 6-3/32" (D) × 19/32" (H)
Weight:	Approx. 97 g (0.22 lb) (including batteries, but not including hard case)
Accessories:	2 lithium batteries (installed), operation manual, quick reference card and hard case

* This value may vary according to the way the calculator is used and other factors.

For More Information about Scientific Calculators

Visit our Web site.

http://sharp-world.com/calculator/

In Europe:

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.

Данное устройство соответствует требованиям директивы 89/336/ЕЕС с учетом поправок 93/68/ЕЕС.

Ez a készülék megfelel a 89/336/EGK sz. EK-irányelvben és annak 93/68/EGK sz. módosításában foglalt követelményeknek.

Tento přístroj vyhovuje požadavkům směrnice 89/336/EEC v platném znění 93/68/EEC.

SHARP CORPORATION

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