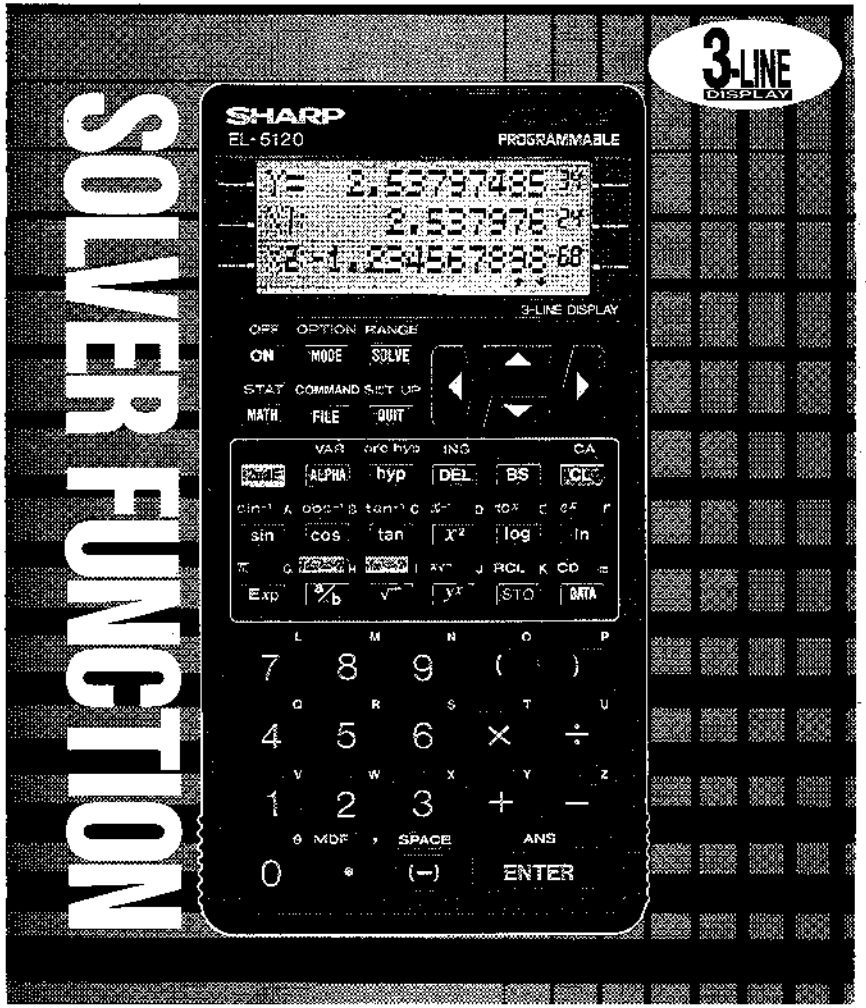
SHARP

EL-5120

PROGRAMMABLE SCIENTIFIC CALCULATOR

OWNER'S MANUAL AND SOLUTIONS HANDBOOK



SHARP CORPORATION

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SHARP EL-5120

PROGRAMMABLE SCIENTIFIC CALCULATOR

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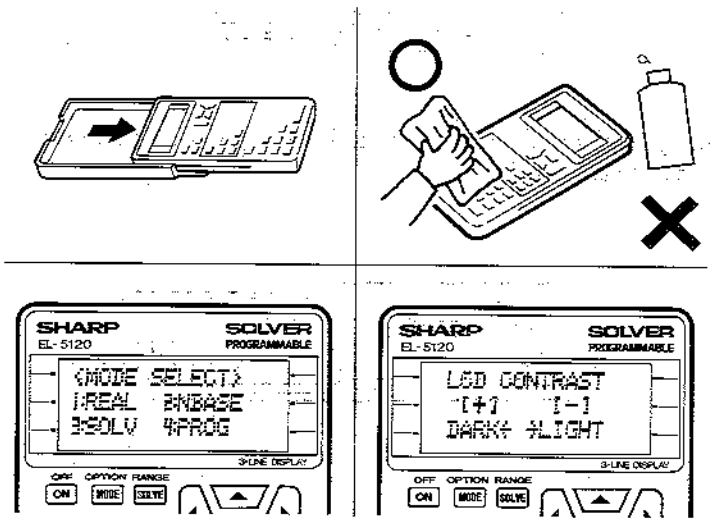
- SHARP strongly recommends that separate permanent written records be kept of all important data. Data may be lost or altered in virtually any electronic memory product under certain circumstances. Therefore, SHARP assumes no responsibility for data lost or otherwise rendered unusable whether as a result of improper use, repairs, defects, battery replacement, use after the specified battery life has expired, or any other cause.

CHAPTER 1:

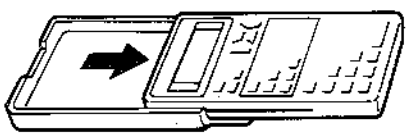
BEFORE YOU GET STARTED



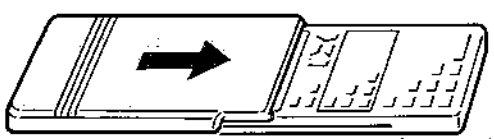
The Protective Cover

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

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

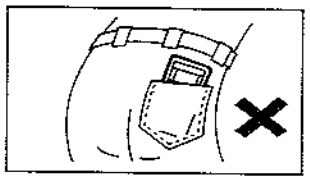


When you are not using the calculator, slide the cover over the keyboard and display as shown.

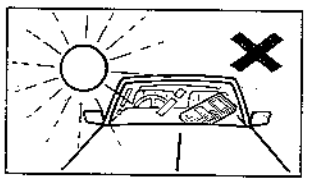


Caring for the Calculator

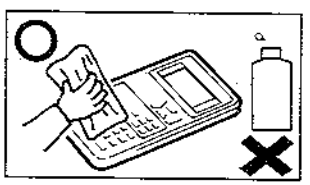
To ensure the trouble-free operation of the calculator, please observe the following points.



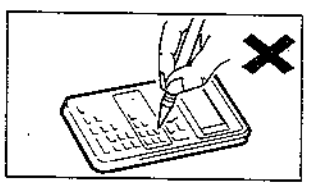
Do not carry the calculator around in your back pocket, as it may break when you sit down. The display is made of glass and is particularly vulnerable.



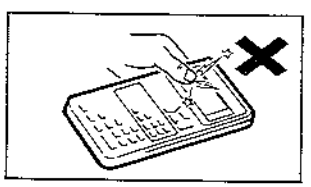
Keep the calculator away from extreme heat, such as on car dashboards or near heaters. Avoid exposing it to excessively humid or dusty environments.



Clean the calculator with a soft, dry cloth. Do not use any solvents.



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



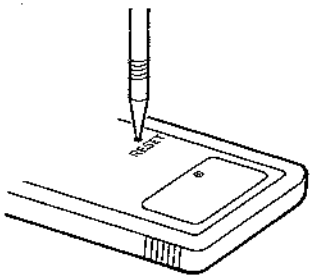
Avoid excessive physical stress.

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. Use the tip of a ball-point pen to press the reset switch on the back of the calculator.



- If you do not see the mesage on the right, the battery may be installed incorrectly; refer to "Replacing the Battery" (p. APP-2) and try installing it again.

```
ALL DATA CL?
 YES→[CL]
  NO→[QUIT]
```

2. Press [CL] and then press any key.
   - The initial display of REAL mode appears.

```
REAL MODE
                0.
```

3. Press [2ndF] [OPTION] [1] and press [+] or [−] to adjust the display contrast until it is set correctly, then press [QUIT].
   - See "OPTION menu" (p. APP-4) for more information regarding optional functions.

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


Operating Modes

The EL-5120 calculator has four operating modes to perform various operations. These modes are selected from the MODE SELECT menu. The sections below show you how to select a mode and what you can do in each mode.

Selecting a mode

1. Press the [MODE] key.
   - The menu display appears. The EL-5120 has a variety of menu displays designed for ease of use.

```
<MODE SELECT>
1:REAL 2:NBASE
3:SOLV 4:PROG
```

2. Press [1] to select REAL mode.
   - In the menu display, press the assigned number to choose or recall a selection.

```
REAL MODE
                0.
```

What you can do in each mode

REAL mode:

Allows you to perform standard calculations, expression solver calculations, integration and statistical operations on real numbers.

NBASE (number base) mode:

Allows you to perform binary, octal, decimal and hexadecimal operations.

SOLV (solver) mode:

Allows you to calculate unknown variables using an equation.

PROG (program) mode:

Allows you to create and use programs to automate simple or complex calculations.

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. It is designed to familiarize you with the calculator's operation keys, display and symbols.

Turning the calculator on and off

1. Press [ON] at the top left 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.

```
REAL MODE
                0.
```

2. Press [2ndF] [OFF ON] to turn the calculator off.
   - Whenever you need to execute a function or command which is written in yellow 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. Press [8] [x^2] [÷] [$\sqrt{}$] [3] [−] [7] [×] [(−)] [1] [0] [•] [5].

```
REAL MODE
                0.
8 ² / √3-7*-10.5_
```


A Quick Tour

- In the display "/" represents [÷] (division) and "*" represents [×] (multiplication).
- This calculator has a minus key [−] for subtraction and a negative key [(−)] for entering negative numbers.
- Note that "√3" is entered in the same order as in a written equation.
- You can review the expression to correct any mistakes in the input numbers or symbols.
- 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 bottom left of the display.
   - In this calculator, you can see both the expression and its answer in the same display.
   - If your answer exceeds 10 digits, the 11th digit will be rounded.
   - The cursor does not have to be at the end of an expression for you to obtain an answer.

```
                0.
8 ² / √3-7*-10.5=
      110.4504172
```

A Quick Tour

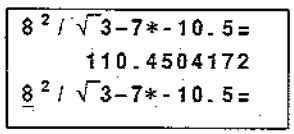
Editing an expression

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.

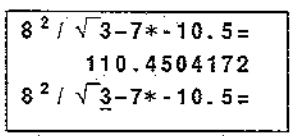
EXAMPLE

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

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, i.e. "=" in this example.

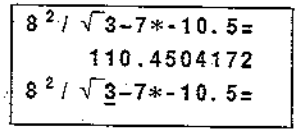


2. Press [▶] four times to move the cursor to the point where you wish to make a change.
   - The cursor has moved four places to the right and is now flashing over "3".

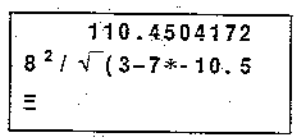


A Quick Tour

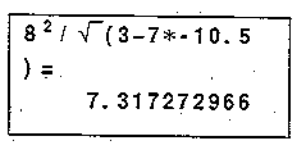
3. Press [2ndF] [INS DEL].
   - This changes the character entering mode from "overwrite" to "insert".
   - When [2ndF] is pressed the 2ndF symbol should appear at the bottom of the display. If it does not, you have not pressed the key firmly enough.
   - The shape of the flashing cursor tells you which 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 onto "=".
   - Note that "=" 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.



A Quick Tour

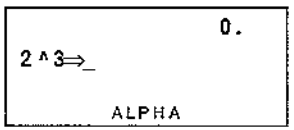
Using variables

You can use 27 variables (A-Z and θ) in all modes. A number stored as a variable can be recalled either by entering the variable name or using [2ndF] [RCL STO].

EXAMPLE 1

Store 2^3 to variable R.

1. Press [CL] [2] [y^x] [3] then [STO].
   - [CL] clears the display.
   - Note that "2^3" represents 2 to the 3rd power.
   - ALPHA appears automatically when you press [STO]. You can now enter any alphabetic character or θ (written in blue above keys in the keypad).

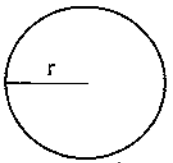


2. Press [R 5] to store the result of 2^3 in R.
   - The stored number is displayed in the next line.
   - ALPHA disappears from the display.

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

A Quick Tour

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



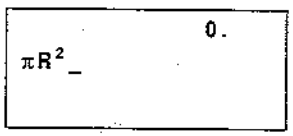
$S = \pi r^2$

EXAMPLE 2

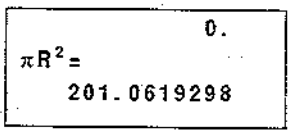
Find the area of a circle which has radius R.

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

2. Press [R 5] and then [x^2].
   - ALPHA disappears after you have entered a character. The calculator returns to normal character entering mode.

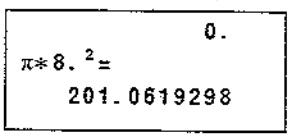


3. Press [ENTER] to obtain the result.



Variable used directly

Instead of entering a variable directly as above, you can use it indirectly, i.e. by recalling it and then using the recalled value. Follow the same procedure as above, but press [×] [2ndF] [RCL STO] instead of [ALPHA] in step 1.
You will get the same result.



Variable used indirectly

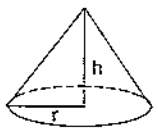
A Quick Tour

Using the expression solver function

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 expression solver function.

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 [CL] [1] [a/b] [3] [2ndF] [π Exp] [ALPHA] [R 5] [x²] [ALPHA] [H a/b] to enter the formula.
   - Note that "1┌3" represents 1 over (i.e. divided by) 3.
   - Variables can be represented only by capital letters.

```
                    0.
1┌3πR²H_
```

2. Press [2ndF] [tx=? √‾] to finish entering the equation.
   - 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.

```
1┌3πR²H=
PRESS[SOLVE]
H=                  0.↓
```


A Quick Tour

3. Press [1] [0] to input the height and go on to the next variable.
   - 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.

```
1┌3πR²H=
PRESS[SOLVE]
R=                  8.↑
```

4. Press [ENTER] to accept the number from memory then press [SOLVE] to obtain the solution.
   - The answer (volume of cone ①) is displayed in the second line.
   - The last variable you entered is displayed in the third line.

```
1┌3πR²H=
    670.2064328
R=                  8.↑
```
Volume of cone ①

5. Press [9] to input the radius for cone ②.
   - The display returns to a value entry screen with "9" substituted for "8" in variable R.

```
1┌3πR²H=

R=9_                  ↑
```

6. Press [ENTER] to confirm the change and press [▲] to move to variable H.
   - Note that "10" is still displayed from last time.

```
1┌3πR²H=
PRESS[SOLVE]
H=                 10.↓
```

7. Press [8] to enter the new height then press [SOLVE] to solve the equation.
   - The volume of cone ② is now displayed.

```
1┌3πR²H=
   678.5840132
H=                  8.↓
```
Volume of cone ②

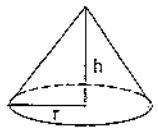
A Quick Tour

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 expression solver function using the same expression as in the last example.

EXAMPLE

What is the height of cone ③ if it has a radius of 9 and the same volume as cone ① (r = 8, h = 10) in the last example.



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

1. Press [MODE] and select SOLV by pressing [3].
   - You are now in solver mode.
   - The phrase "SOLVER MODE" appears on the display as a reminder when you select SOLV.
   - Since there is no expression yet entered in this mode, the calculator asks you to input an expression.

```
SOLVER MODE
```

⇩

```
EQUATION?
```

2. Press [ALPHA] [1] (V) [ALPHA] [DATA] (=) then input the rest of the expression.
   - Enter the rest of the expression in the same way as for the expression solver function. However, note that you must press [ALPHA] [DATA] (=), not [ENTER], to enter the = sign.

```
V=1/3πR²H_
```

3. Press [ENTER] to move to the variable input display.
   - Note that the values assigned to the variables in the last example for the expression solver function are picked up and displayed in the SOLVER mode.

```
H=          8.
R=          9.
V=          0.
```

Variables from the expression solver function

A Quick Tour

4. Press [1] [0] to input the height of cone ①.
   - First of all, you must find the volume of cone ① again.

```
H=10_
R=          9.
V=          0.
```

5. Press [ENTER] to enter the height and press [8] [ENTER] to enter the radius.
   - The cursor is now on V.

```
H=         10.
R=          8.
V=          0.
```

6. Press [SOLVE] to find the value of V.
   - R→ and L→ are the values computed by Newton's method, which is used to determine the accuracy of the solution.
   - Note that the calculator finds the value of the variable which the cursor is on when you press [SOLVE].

```
V= 670.2064328
R→ 670.2064328
L→ 670.2064328
```

Right and left sides of the expression after substituting the known variables

Volume of cone ①

7. Press [QUIT] to go back to the variable input display.
   - This time the value of V from memory is also displayed.

```
H=         10.
R=          8.
V= 670.2064328
```

8. Press [▲] to accept the displayed value of V and press [9] [ENTER] to input the radius of cone ③.

```
H=         10.
R=          9.
V= 670.2064328
```

9. Press [▲] [▲] [SOLVE] to find the height of cone ③.
   - Now you have the height of cone ③, which has the same volume as cone ①.

```
H= 7.901234568
R→ 670.2064328
L→ 670.2064328
```

Height of cone ③

A Quick Tour

Other features

Your calculator has a range of other features that can be used in various situations, and can perform many calculations other than those we went through in the quick tour. Some of the important features are as follows.

- **Statistics:**
  You can perform one- and two-variable weighted statistical calculations. Statistical results include mean, sample standard deviation, population standard deviation, sum of data, and sum of squares of data. (☞ Chapter 5)

```
n=              10.
r=
     0.983215286
```

- **Number Base:**
  You can perform binary, octal, decimal or hexadecimal operations. You can convert numbers from any of these bases to any other. (☞ Chapter 6)

```
D6→BIN
        00000000
        11010110
```

- **Numerical Integration**
  You can perform integration using Simpson's rule. (☞ Chapter 7)

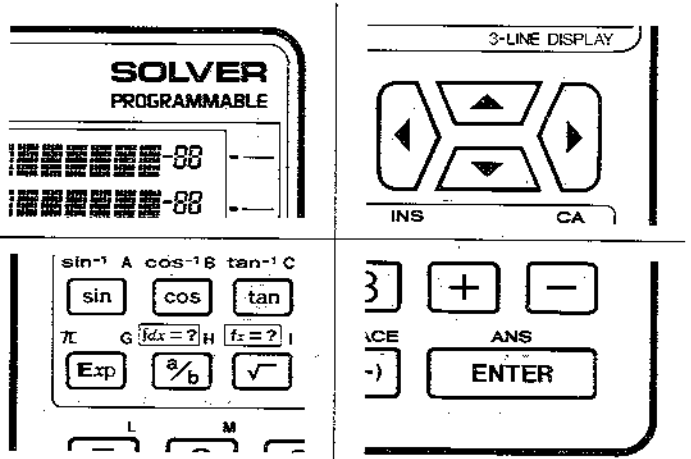
```
2X²+3X
∫ dx=
                64.5
```

- **Programming:**
  You can program your calculator to automate certain calculations. Each program can be used in both REAL and NBASE modes. (☞ Chapter 8)

```
INPUT C
F=(9/5)*C+32
PRINT F
```

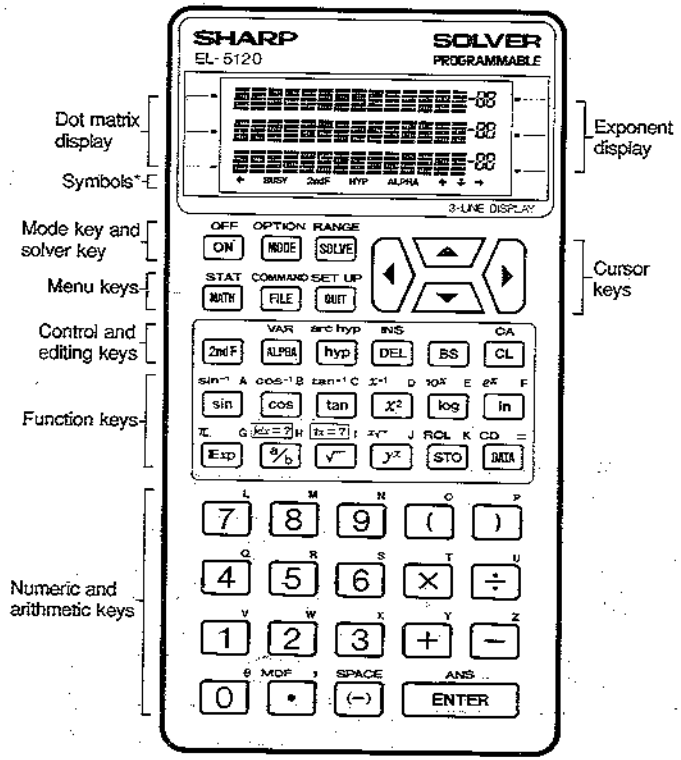

CHAPTER 2:

KEYS AND DISPLAY



Calculator Layout

The calculator display consists of a 16 digit × 3 line display plus various symbols. Each 16-digit display line consists of a 14 character dot matrix display (5 × 5 dots per character) and a 2-digit exponent display.
The keys are classified as mode key, solver key, menu keys, cursor keys, control and editing keys, function keys, and arithmetic keys.



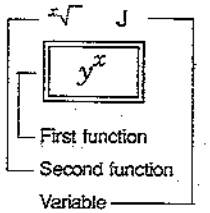
* During use, these symbols are never all displayed at the same time.

Calculator Keys

There are three broad groups of key function: ① first function, ② second function, and ③ variable.

Key notation in this manual

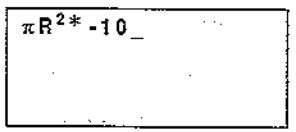
To perform the second or variable functions shown in yellow or blue above the keys, you have to press [2ndF] or [ALPHA] followed by the key.
The notation used for key operations henceforth in this manual is shown below.



EXAMPLE

Enter the expression: $\pi R^2 \times -10$

Press: [π] [R] [x^2] [×] -10



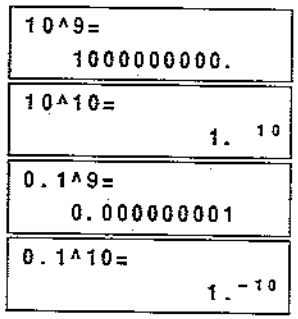
- Second functions and variables such as π and R are shown in brackets [ ]. This means you have to press [2ndF] followed by [$\overset{\pi}{\text{Exp}}$] and [ALPHA] followed by [$\overset{R}{5}$].
  If a function expressed within [ ] is written in yellow on the keypad, press [2ndF] (the yellow key) followed by the key below the function; if it is written in blue, press [ALPHA] (the blue key) followed by the key below the function.
- First functions, except for those of the numeric, decimal point and negative keys, are shown within a box.
  Number entries are shown in boxes if they are being used to select menu options from the display.

Calculator Display

The calculator has a 16 digit × 3 line display able in many cases to display an equation and its solution in the same screen or guide you via a menu display. There are also symbols to indicate the status of the calculator.

Display structure

When you enter an expression of up to 14 characters, it will be displayed in dot matrix form on one line. The other two digits of the line are used to display the exponent part of the answer if it exceeds 10 digits. If your expression exceeds 14 digits, the display continues it on the next line. The answer is always displayed on the next line after the equals sign which marks the end of the expression.



If the result is not between -9999999999 and -0.000000001, between 0.000000001 and 9999999999 or 0 the display automatically changes to scientific notation.

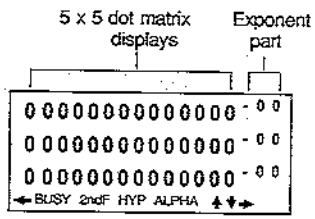
Meaning of the symbols

← or → appears in program mode if a statement exceeds 14 characters. The display text scrolls to the left as additional characters are keyd in and ← lets you know that part of the statement is off the display to the left.

↑ or ↓ appears if an expression or equation exceeds 3 lines to let you know that part of it is off the top or bottom of the display.

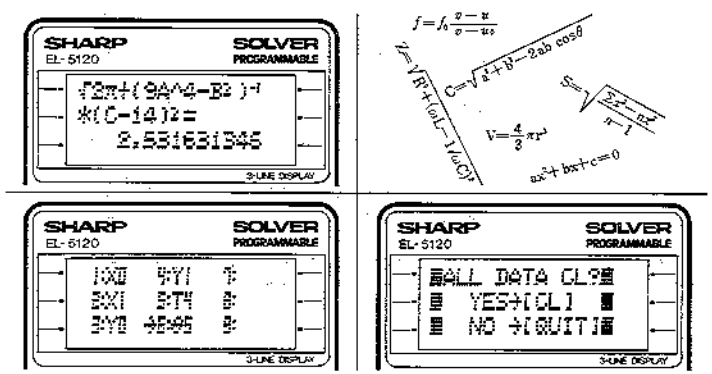
BUSY is displayed while the calculator is computing the solution.

2ndF, **HYP** or **ALPHA** appears when you press [2ndF], [HYP] or [ALPHA] respectively to confirm the key function mode that the calculator is in.



CHAPTER 3:

GENERAL INFORMATION



Precedence

The calculator always performs calculations in the standard arithmetic order, even though this may not be the order in which you entered them.

D.A.L. (Direct Algebraic Logic)

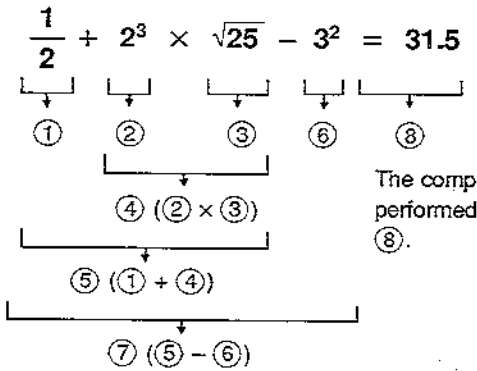
SHARP's Direct Algebraic Logic uses the following order of precedence in solving an expression.

PRECEDENCE	OPERATION	EXAMPLE
Highest	• Fraction operation	$\frac{1}{2}$
	• Functions that follow an entry	n!, x^2, x^{-1}
	• Power functions y^x	10^5
	• Implied multiplication with π or a variable	4π, 6R
	• Functions that precede an entry	sin 45, $\sqrt{9}$
	• Implied multiplication with a function	5sin, 2ln
	• Permutation and combination	15P3, 15C3
	• Multiplication and division	3 × 4 ÷ 6
	• Addition and subtraction	2 + 3 − 4
	• Logical AND	1100 AND 1011
	• Logical OR, XOR or XNOR	C XNOR 9
	• Change to rectangular or polar coordinates	7, 15→rθ 10.5, 25→xy
Lowest	• Storing to memory, or equals	10⇒R, 2^2=

Precedence

D.A.L. procedure

Let us examine the order in which the calculator performs the operations of a computation.



The computation is performed in the order ① – ⑧.

Using parentheses

You may change the order of calculation using parentheses ([(] and [)]). Parentheses are entered as they would appear in a written equation. Expressions within parentheses are always computed first.

$$\frac{1}{2} + 2^3 \times (\sqrt{25} - 3^2) = -31.5$$

You may skip the operation of pressing [)] if and only if the closing parenthesis comes just before [ENTER] or [STO], as in the above expression.

```
1┌2+2^3*(√25-3
^2=
                -31-1┌2
```

Pending operations

The calculator can store up to 16 pending operations and up to 8 numbers.

Correcting Mistakes

Mistakes can be corrected in several ways. The keys you use for correction depend on the type of mistake.

The cursor keys

Incorrect keystrokes may be changed by using the cursor keys ◄ ►.

EXAMPLE

Enter 123456 then correct it to 123459.

1. Press [CL] 123456.

```
                    0.
123456_
```

2. Press [◄] 9 [ENTER].

```
                    0.
123459=
          123459.
```

The edit keys

There are two editing keys: [DEL] and [BS]. [DEL] deletes the character under the cursor in the display. [BS] deletes the character just before the cursor in the display.

EXAMPLE

Enter 123456 then correct it to 1235.

1. Press [CL] 123456.

```
                    0.
123456_
```

2. Press [BS] [◄] [◄] [DEL] [ENTER].

```
                    0.
1235=
          1235.
```


Correcting Mistakes

Editing modes

There are two editing modes: overwrite mode and insert mode. The default setting is overwrite mode, and insert mode must be selected by pressing [INS].

You can tell which mode you are in by the shape of the flashing cursor in the display.

Shape of the cursor in overwrite mode.

Shape of the cursor in insert mode.

EXAMPLE

Enter 123456 then correct it to 1239456.

1. Press [CL] 123456.

```
                    0.
123456_
```

2. Press [◄] [◄] [◄] [INS] 9 [ENTER].

```
                    0.
1239456=
          1239456.
```

You can also correct entries by pressing [CL] to clear the screen then typing the corrected entry.

The SET UP Menu

The SET UP menu lets you change the angular unit, the display format, the way fractional results are displayed and the statistical format.

The SET UP display

After pressing [SET UP], the menu display appears.

```
   <SET UP>
1:DEG    2:FLOAT
3:MIXED  4:STATx
                ▼
```

- The menu displays the current settings of all the SET UP options.
- If you wish to change the SET UP conditions, press the number to the left of the relevant condition or scroll the screen using [▼] until the desired sub-menu appears.
- Press [QUIT] to return to the mode you left.

Angular unit (degrees/radians/grads)

Press [1] in the SET UP menu to call the DRG menu. This menu lets you select the angular units for trigonometric functions.

```
DRG[DEG]
1:DEG    2:RAD
3:GRAD
              ▲▼
```

- The title of the menu and the current setting appears in the first line of the display.
- Press [1], [2] or [3] to select degrees, radians or grads, respectively. A circle is divided into 360 degrees, 2π radians or 400 grads.
- Once you have changed a condition, the display automatically goes back to the SET UP menu.

The SET UP Menu

Display format and decimal places (floating/fixed/scientific/engineering)

Press [2] in the SET UP menu to call the FSE menu. This menu lets you select one of four different display formats. You need not worry about entering numbers in the appropriate display format since these formats only affect the way the numeric results are displayed.

```
FSE[FLOAT]
1:FLOAT 2:FIX
3:SCI   4:ENG
              ▲▼
```

- The title of the menu and the current setting appears in the first line of the display.
- Press [1], [2], [3] or [4] to select floating-point, fixed-point, scientific or engineering format, respectively.
- If you choose 2:FIX, 3:SCI or 4:ENG, the display changes automatically to the TAB menu.
- Press [0], [1], ... [8] or [9] to set the desired number of decimal places.

```
TAB[9]
0:0  1:1  2:2  3:3  4:4
5:5  6:6  7:7  8:8  9:9
              ▲▼
```

The following table shows the differences in the display for the four formats.
It shows the answer to the expression 1.2345×67890.

Display format	1:FLOAT	2:FIX	3:SCI	4:ENG
Answer displayed	83810.205	83810.20500	8.381020500 04	83.81020500 03
Actual answer	83810.205	83810.205	8.3810205×10^{4}	83.810205×10^{3}
Answer displayed when TAB = 2	83810.205	83810.21	8.38 04	83.81 03
Actual answer	83810.205	83810.21	8.38×10^{4}	83.81×10^{3}

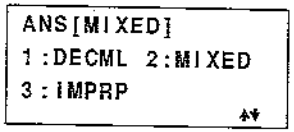
- Note that the number of decimal places affects the result of the modify command [mdf]. (☞ p. 42)

The SET UP Menu

Fraction results

Press [3] in the SET UP menu to call the ANS menu. This menu lets you select the way fractional answers are displayed.

- The title of the menu and the current setting appear in the first line of the display.
- Press [1], [2] or [3] to select whether the result is in decimal form, mixed numbers or improper form, respectively.

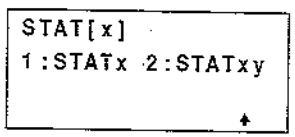


"Using Fractions" in Chapter 4 explains how to enter and edit fractional calculations.
(☞ p. 37)

Statistical format

Press [4] in the SET UP menu to call the STAT menu. This menu lets you choose between one or two variables (STATx or STATxy) for statistical calculations.

- The title of the menu and the current setting appears in the first line of the display.
- Press [1] or [2] to select one or two variables, respectively.



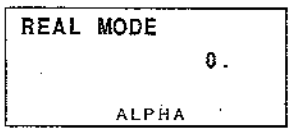
Each entry in both one-variable and two-variable statistics can hold weighted or unweighted data.
(☞ p. 52)

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 bottom of the display. To enter this mode, press [ALPHA].



Using global variables indirectly

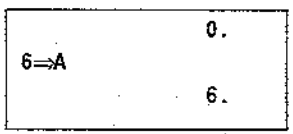
You can assign values (numbers) to global variables by pressing [STO] then A – θ.

EXAMPLE 1

Store 6 to global variable A.

Press: [CL] 6 [STO] A

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



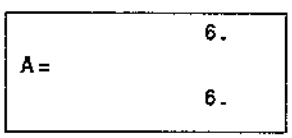
To recall global variables, press [RCL] then A – θ.

EXAMPLE 2

Recall global variable A.

Press: [RCL] A

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



Using Memories

Using local variables indirectly

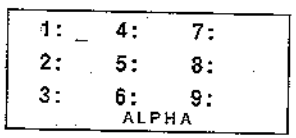
Nine local variables can be used in each equation or program, in addition to the global variables. Unlike global variables, the values of the local variables will be stored with the equation when you save it.

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.

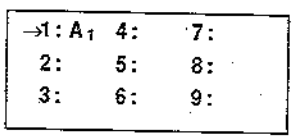
EXAMPLE

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

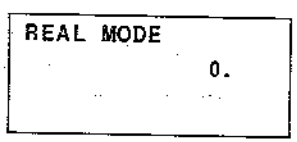
1. Press [VAR].
   - The VAR menu appears.
   - If no local variables are stored yet, ALPHA appears automatically and the calculator is ready to enter a name.



2. Press A 1 [ENTER].
   - → shows that you have finished assigning the name A1.
   - To assign more names, press [▼] to move the cursor to VAR 2 and repeat the process above.

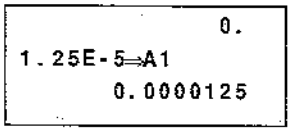


3. Press [QUIT].
   - This returns you to the previous screen.

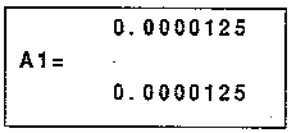


Using Memories

4. Press 1.25 [Exp] -5 [STO] [VAR] [1].
   - Unlike for global variables, you do not need to enter any alphabetic characters. Just specify the named local variable using a number from 1 to 9, or move the arrow to the appropriate variable then press [ENTER].



5. Press [VAR] [1] [ENTER].
   - The value of VAR 1 will be recalled.
   - Alternatively you can recall a variable by moving the arrow to it then press [ENTER].



You can change the name of a local variable by overwriting it in the VAR menu.

Although the procedure to name variables is essentially the same in other modes as in REAL mode, the values of the local variables may have to be entered at a different stage in the procedure. The following table shows you when to enter the values in other modes.

Mode	When to input the value
REAL	As above
: Expression solver	In the display for entering or editing variables
NBASE	As above
SOLVER	In the display for entering or editing variables
PROGRAM	Substitute the values for the variables during the program or use the "input" command

In all modes, pressing [CA] will clear the equation or program along with all its local variables.

Using Memories

Using variables directly

Both global and local variables can be used directly in an equation or a program. The names of local variables should be chosen bearing in mind that you may need to use a variable like X_1 or X_2 at the same time.

EXAMPLE

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

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

1. Press [CL] 1 [a/b] .
   - Begin entering the expression as if it were a normal equation.

```
                    0.
1 r_
```

2. Press [VAR].
   - The VAR menu display appears but the calculator remembers what you entered before you pressed [VAR].

```
→1:A1  4:     7:
 2:    5:     8:
 3:    6:     9:
```

3. Press [1] [−] 1000 [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.

```
                    0.
1 rA1-1000A=
              74000.
```

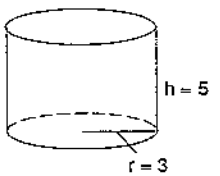

Using Memories

Using "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 [ENTER] . 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 "last answer".



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

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

2. Press [CL] 5 [ANS] [ENTER] .
   - You now have the volume of the cylinder.
   - The last answer is not cleared merely by pressing [CL] .

```
                    0.
5 ANS=
      141.3716694
```

The last answer is cleared (i.e. set to 0) if you press [CA] or the RESET switch or change the mode, but not if you turn the calculator off.

Resetting the Calculator

If you wish to clear all memories, variables and data, or if none of the keys (including [ON]) 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.

1. Press the RESET switch.
   - A display appears asking you to confirm that you really want to reset the calculator.

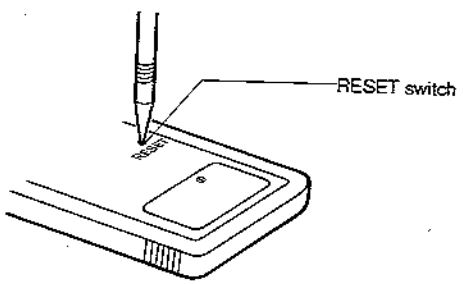
```
ALL DATA CL?
 YES→[CL]
  NO→[QUIT]
```

2. Press [CL].
   - All memories, variables and data are cleared.
   - The calculator will revert to the very first settings that were made when you started to used the calculator for the first time.

```
   ALL DATA
   CLEARED!
HIT ANY KEY
```

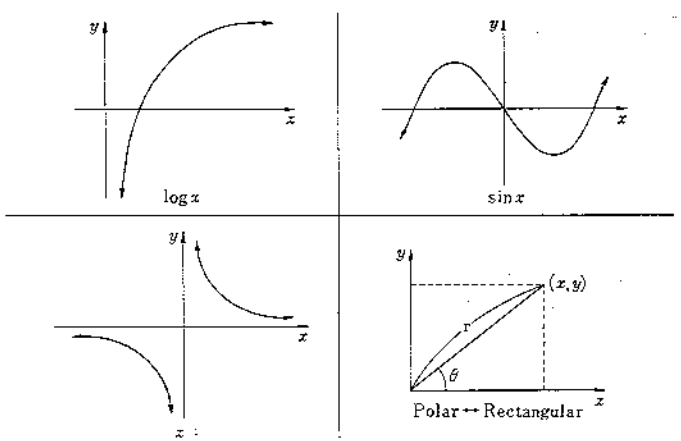
3. To cancel the operation, press [QUIT].
   - The display goes back to the initial display in the REAL mode.
   - The ANS memory will be cleared.

```
REAL MODE
                0.
```



CHAPTER 4:

MATHEMATICAL OPERATIONS



REAL Mode

REAL mode is used for standard calculations, and has the widest variety of functions. Many of the functions described in this chapter can, however, also be used in other modes.

Press [MODE] [1] to select REAL mode. You can enter an equation in the same way as it would be written using D.A.L. (☞ p. 22)

Expression solver (☞ p. 68), numeric integration (☞ p. 72) and statistical calculations (☞ p. 49) as well as the basic mathematical operations described in this chapter can be performed in REAL mode.

Pi

Pi (π) is stored as a constant in the calculator. Pressing [π] recalls the symbol π to the display; the value 3.14159265359 is used in calculations. However, only the first 10 digits of the result will be displayed after calculation.

EXAMPLE

Compare π^2 and 3.141592654^2.

1. Press [CL] [π] [x^2] [ENTER].
   - The answer will be 9.869604401 as a result of squaring 3.14159265359.

```
                0.
π²=
    9.869604401
```

2. Press 3.141592654 [x^2] [ENTER].
   - The calculator squares 3.141592654, giving 9.869604404 as the result.

```
    9.869604401
3.141592654²=
    9.869604404
```


Using Fractions

Calculations can be performed using decimal, mixed or improper fractions.

Entering and converting fractions

To enter a proper fraction (e.g. $\frac{1}{2}$) or an improper fraction (e.g. $\frac{3}{2}$), enter the numerator, press [a/b] then enter the denominator.

To enter a mixed fraction (e.g. $2\frac{2}{3}$), enter the integer part, press [+], enter the numerator, press [a/b] then enter the denominator.

EXAMPLE 1

Find the answer to the expression $\frac{5}{3} + 2\frac{1}{6}$.

Press [CL] 5 [a/b] 3 [+] 2 [+] 1 [a/b] 6 [ENTER].

- $\frac{5}{3}$ is displayed as 5┌ 3 and $2\frac{1}{6}$ as 2 + 1 ┌ 6.
- The answer 3 + 5┌ 6 can be written as $3\frac{5}{6}$.

```
                0.
5┌3+2+1┌6=
              3+5┌6
```

You can convert between decimal, mixed and improper fractions in the SET UP menu. (☞ p. 26)

EXAMPLE 2

Convert the last answer, 3 + 5┌ 6, from mixed to improper form.

Press [SET UP] [3] [3] [QUIT].

- The answer is now also displayed in improper form. All subsequent answers will be displayed in improper form only.

```
5┌3+2+1┌6=
              3+5┌6
               23┌6
```

Power Functions

You can perform standard power and root calculations using [x^2], [y^x], [$\sqrt{}$], [$\sqrt[x]{}$] and [x^{-1}].

The following table describes the operation of the power function keys.

Function	Description	Example	Display
[x^2]	Calculates the square of a number.	3 [x^2] ENTER	3 ^ 2 = 9.
[y^x]	Raises a number y to the power of a second number x.	4 [y^x] 5 ENTER	4 ^ 5 = 1024.
[$\sqrt{}$]	Calculates the square root of the number that follows it.	[$\sqrt{}$] 27 ENTER	√ 27 = 5.196152423
[$\sqrt[x]{}$]	Calculates the xth root (x is the number entered before the operation key) of the number that follows it.	5 [$\sqrt[x]{}$] 243 ENTER	5 x √ 243 = 3.
[x^{-1}]	Calculates the reciprocal of a number.	0.25 [x^{-1}] ENTER	0 . 25 ^ -1 = 4.

Logarithms and Exponentials

You can calculate common (base 10) and natural (base *e*) logarithms and exponentials (antilogarithms) using [log], [ln], [10^x], and [e^x].

The following table describes the operation of the logarithm and exponential function keys.

Function	Description	Example	Display
[log]	Calculates the base 10 logarithm of a number.	[log] 31.62 ENTER	log 31.62= 1.499961866
[ln]	Calculates the base e logarithm of a number.	[ln] 31.62 ENTER	ln 31.62= 3.453789832
[10^x]	Raises 10 to the power of a number.	[10^x] 4.7 ENTER	10 ^ 4.7 = 50118.72336
[e^x]	Raises e to the power of a number.	[e^x] 1 ENTER	e ^ 1 = 2.718281828

Trigonometric Functions

You can calculate trigonometric functions and their inverses for angles measured in degrees, radians or grads.

Selecting angular units

A circle has 360°, 2π radians or 400 grads. To select degrees, radians or grads, press [SET UP] [1] to recall the DRG menu. (☞ p. 26)

```
DRG[DEG]
1:DEG    2:RAD
3:GRAD
```

Sines, cosines and tangents

[sin], [cos] and [tan] calculate the sine, cosine and tangent, respectively, of a number. When using these keys, be sure the calculator is set for the angular unit you want to work with.

EXAMPLE

Calculate sin 30°, cos $\frac{\pi}{2}$ radians and tan 150 grads.

1. Press [CL] [SET UP] [1] [1] [QUIT] [sin] 30 [ENTER].
   - Pressing [SET UP] [1] [1] [QUIT] sets the angle to DEG.

```
                0.
sin 30=
                0.5
```

2. Press [SET UP] [1] [2] [QUIT] [cos] [π] [a/b] 2 [ENTER].
   - Pressing [SET UP] [1] [2] [QUIT] changes the angle to RAD.

```
                0.5
cos π┌2=
                0.
```

3. Press [SET UP] [1] [3] [QUIT] [tan] 150 [ENTER].
   - Pressing [SET UP] [1] [3] [QUIT] changes the angle to GRAD.

```
                0.
tan 150=
               -1.
```


Trigonometric Functions

Inverse trigonometric functions

[$\sin^{-1}$], [$\cos^{-1}$] and [$\tan^{-1}$] calculate the arcsine, arccosine and arctangent of the number. The result is always the smallest (positive or negative) angle that has a sine, cosine or tangent equal to the operand. You must set the desired angle unit beforehand.

sin 30°
sin 150°
sin –210°
sin –330°
— 0.5

$\sin^{-1}$ 0.5 = 30°

EXAMPLE

Calculate arcsine -1 in degrees.

Press [CL] [SET UP] [1] [1] [QUIT] [$\sin^{-1}$] -1 [ENTER].

- Pressing [SET UP] [1] [1] [QUIT] sets the angle unit to DEG.

```
                0.
sin⁻¹ -1=
              -90.
```

Hyperbolic functions

You can select hyperbolic sines, cosines, tangents and their inverses by pressing [hyp] or [arc hyp] followed by [sin], [cos] or [tan].

EXAMPLE

Find the hyperbolic cosine of 0 and the inverse hyperbolic sine of 7.544.

1. Press [CL] [hyp] [cos] 0 [ENTER].
   - HYP appears at the bottom of the display when you press [hyp].
   - The hyperbolic cosine is displayed as "cosh".

```
                0.
cosh 0=
                1.
```

2. Press [arc hyp] [sin] 7.544 [ENTER].
   - Both 2ndF and HYP appear at the bottom of the display when you press [arc hyp].

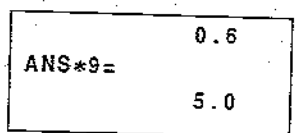
```
                1.
sinh⁻¹ 7.544=
    2.718263812
```

Modify Function

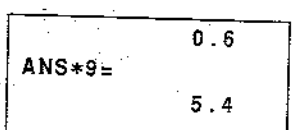
The calculator holds all calculation results internally in scientific notation, with up to 12 digits for the mantissa.

The modify function converts the internal value (12 decimal places) to match that of the display (no. of decimal places selected in the SET UP menu), so that the displayed value can be used exactly as you see it in subsequent operations. This function is useful for calculations in which not all the significant digits of a number need to be taken into account.
If the modify function is not used, the internal result rather than the displayed result is used in subsequent calculations.

1. Press [SET UP] 2 2 1 QUIT.
   - Set the display to FIX format with one decimal place.
2. Press 5 ÷ 9 ENTER × 9 ENTER.
   - The calculator obtains 0.555555555556 as the internal result of 5 ÷ 9 and displays it as 0.6.
   - The internal result is multiplied by 9 to give a result of 5.0 (the first number you entered).



3. Press 5 ÷ 9 ENTER [MDF] × 9 ENTER.
   - The modify function substitutes the displayed result (0.6) for the internal result.
   - The calculator multiplies 0.6 by 9 to give 5.4

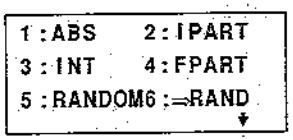


Math Menu Functions

There are other functions available on this calculator besides the first and second functions on the key pad. These other functions are accessed using the math function menu. The math menu has different contents for each mode. In REAL mode, you can recall the following functions via the math menu.

Absolute values, integers and parts of numbers

Press MATH to call the first page of the math menu display. In this menu, press 1, 2, 3 or 4 to select functions, that is to find the absolute value, integer part, integer value, or fractional part of a number, respectively.



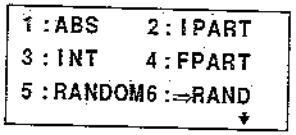
The following table describes the operation of these functions.

Function	Description	Example	Display
1:ABS	Displays the absolute value of a number.	MATH 1 -7 ENTER	ABS -7= 7.
2:IPART	Displays the integer part only of a number.	MATH 2 -7.94 ENTER	IPART -7.94= -7.
3:INT	Displays the largest integer less than or equal to a number.	MATH 3 -7.94 ENTER	INT -7.94= -8.
4:FPART	Displays the fractional part only of a number.	MATH 4 -7.94 ENTER	FPART -7.94= -0.94

Math Menu Functions

Random numbers

Press [MATH] to call the first page of the math menu display. In this menu, press [5] to select a random number and [6] to select random number lists.



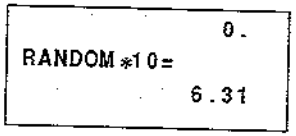
The calculator can pick random numbers between 0 and 0.999.

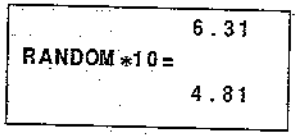
EXAMPLE

Pick a random number between 0 and 9.99.

Press [CL] [MATH] [5] [×] 10 [ENTER].

- The result may not be the same each time this operation is performed.
- Pressing [×] 10 multiplies the generated random number (in the range 0–0.999) by 10 to give a random number in the range 0–9.99.
- The calculator will continue to pick random numbers between 0 and 9.99 for each subsequent press of [ENTER].





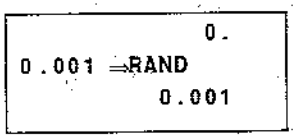
Math Menu Functions

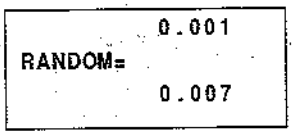
The calculator has 999 lists of random numbers (numbered from 0.001 to 0.999). These hold the same random numbers for each calculator, and can be used to share random numbers with other EL-5120 users.

EXAMPLE

Have the calculator pick a random number from list 0.001.

1. Press [CL] 0.001 [MATH] [6].
   - The random list 0.001 is selected and its first number will be recalled by pressing [MATH] [5].
2. Press [MATH] [5] [ENTER].
   - The calculator recalls the first number of the list. The numbers are always recalled in the same order.





If you wish to go back to the normal random number function, press 0 [MATH] [6].

Math Menu Functions

Factorials, combinations and permutations

Press [MATH] [▼] to call the second page of the math menu display. In this display, press [1], [2] or [3] to select functions, that is to find factorials, combinations or permutations, respectively.

```
1:n!      2:nCr
3:nPr
```

The following table describes the operation of these functions.

Function	Description	Example	Display
1:n!	Calculates the factorial of an integer value.	7 [MATH] [▼] [1] [ENTER]	7!= 5040
2:nCr	No. of combinations. Finds the number of possible groups or r items that can be extracted from a group of n items.	3 [MATH] [▼] [2] 2 [ENTER]	3C2= 3
3:nPr	No. of permutations. Finds the number of possible arrangements of r items that can be extracted from a group of n items.	3 [MATH] [▼] [3] 2 [ENTER]	3P2= 6

Math Menu Functions

Degrees ↔ DMS conversion

Press [MATH] [▼] [▼] to call the third page of the math menu display. In this menu, press [1] or [2] to convert the angle unit to degrees (decimal notation) or DMS (degrees, minutes, seconds).

```
1:→DEG    2:→DMS
3:→rθ     4:→xy
```

The display format for each notation is as follows.

- Degrees:
  D.ddddddddd
  - Fraction of a degree (maximum of 9 decimal places)
  - Integral number of degrees (°)
- DMS:
  D.MMSSss
  - Fraction of a second (maximum of 2 decimal places)
  - Seconds (″)
  - Minutes (′)
  - Integral number of degrees (°)

The following table describes the operation of the degrees ↔ DMS conversion functions.

Function	Description	Example	Display
1:→DEG	Converts from DMS to decimal format.	7.5624 [MATH] [▼] [▼] [1] [ENTER]	7.5624→DEG = 7.94
2:→DMS	Converts from decimal to DMS format.	7.94 [MATH] [▼] [▼] [2] [ENTER]	7.94→DMS = 7.562400

- In decimal notation, the number 7.94 in the display means 7.94°.
- In DMS notation, the number 7.562400 in the display means 7°56′24.00″.

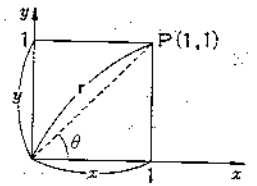
Math Menu Functions

Polar ↔ rectangular conversion

Press [MATH] [▼] [▼] to call the third page of the math menu display. In this menu, press [3] or [4] to convert to polar (r, θ) or rectangular (x, y) coordinates.

```
1 :→DEG   2 :→DMS
3 :→rθ    4 :→xy
                ▲
```

Since the angle unit affects the value of θ when you perform conversions, be sure to set the angle unit you wish to work with in the SET UP menu. (☞ p. 26)



EXAMPLE 1

Convert the rectangular coordinates (1,1) to polar coordinates (with θ expressed in degrees).

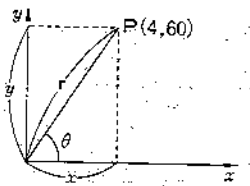
Press [SET UP] [1] [1] [QUIT] 1 [,] 1 [MATH] [▼] [▼] [3].

```
1 ,1→rθ
r=  1.414213562
θ=          45.
```

- The polar coordinates are automatically stored in global variables R and θ.

EXAMPLE 2

Convert the polar coordinates (4,60°) to rectangular coordinates.



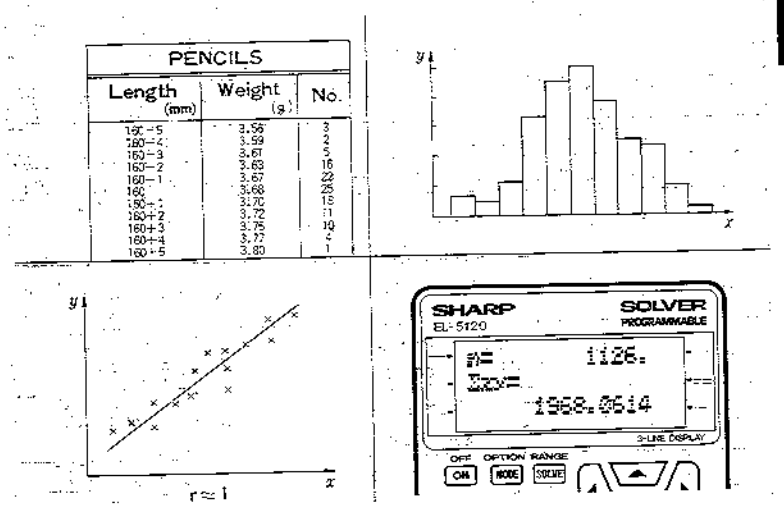
Press [SET UP] [1] [1] [QUIT] 4 [,] 60 [MATH] [▼] [▼] [4].

```
4 ,60→xy
x=          2.
y=  3.464101615
```

- The rectangular coordinates are automatically stored in global variables X and Y.

CHAPTER 5:

STATISTICAL OPERATIONS



Statistics

You can perform a number of one-variable or two-variable statistical operations in REAL mode.

The following table describes the statistical functions that can be performed.

Function: One-variable	Function: Two-variable	Description	Key operations
$\bar{x}$	$\bar{y}$	Mean value of samples $\bar{x} = \frac{\Sigma x}{n}$, $\bar{y} = \frac{\Sigma y}{n}$	$\bar{x}$: [STAT] 1 $\bar{y}$: [STAT] ▼ 1
sx	sy	Sample standard deviation $sx = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n-1}}$, $sy = \sqrt{\frac{\Sigma y^2 - n\bar{y}^2}{n-1}}$	sx : [STAT] 2 sy : [STAT] ▼ 2
σx	σy	Population standard deviation $\sigma x = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n}}$, $\sigma y = \sqrt{\frac{\Sigma y^2 - n\bar{y}^2}{n}}$	σx : [STAT] 3 σy : [STAT] ▼ 3
Σx	Σy	Sum of samples	Σx : [STAT] 4 Σy : [STAT] ▼ 4
Σx^2	Σy^2	Sum of squares of samples	Σx^2 : [STAT] 5 Σy^2 : [STAT] ▼ 5
n	n	Number of samples	n : [STAT] 6
—	Σxy	Sum of products of samples	Σxy : [STAT] ▼ 6
—	a	$a = \bar{y} - b\bar{x}$ Coefficients of linear regression equation $y = a + bx$	a : [STAT] ▼ ▼ 1
—	b	$b = \frac{Sxy}{Sxx}$	b : [STAT] ▼ ▼ 2
—	r	$r = \frac{Sxy}{\sqrt{Sxx \cdot Syy}}$ Correlation coefficient	r : [STAT] ▼ ▼ 3
—	x′	$x' = \frac{y - a}{b}$ Value estimated by substituting for y	x′ : y [STAT] ▼ ▼ 4
—	y′	$y' = a + bx$ Value estimated by substituting for x	y′ : x [STAT] ▼ ▼ 5

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

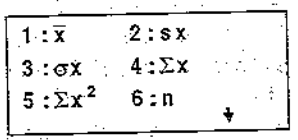
STAT Menu Display

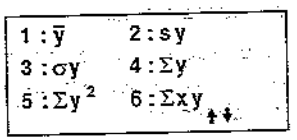
Statistical operations are selected from the STAT menu display. However, you must input your data before you proceed to the statistical operations. (☞ p. 52)

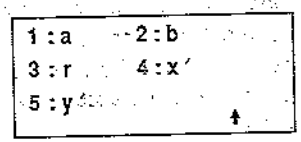
The menu display

Pressing [STAT] calls the STAT menu display. If you select STATx (for one-variable operations), then the STAT menu consists of only one page (the first of its three pages). If you select STATxy (for two-variable operations), all three pages of the menu are available by pressing ▼.

The first page of the STAT menu consists mainly of statistical functions of variable x; these can be used for both one- and two-variable statistics. The second page consists of functions involving variable y for use in two-variable statistics, and the third page consists of linear regression functions.







Selecting statistics

Please refer to the table of statistical functions on the previous page for the key operations to select the required operation. After selecting a function, press [ENTER] to find its value.

Data Entry and Correction

You can input one-variable or two-variable statistical data in the form in which it would normally be written, i.e. entry, entry, entry. You can also input weighted data instead of having to repeat identical entries.

Before data entry

Select one-variable (x) or two-variable (x,y) statistics in the SET UP menu. (☞ p. 28) The calculator clears all the data if you switch between one-variable and two-variable mode.

```
<SET UP>
1:DEG  2:FLOAT
3:DECML 4:STATx
```

When you are in the appropriate mode, press [CA] to clear any data and results left in the memory.

Once the result of a statistical operation has been obtained, additional information can be entered and the operation can be performed using successive additional data entries.

Data entry

The following table shows how to enter one- and two-variable data sets.

Mode	Example	Final display
x	[SET UP] [4] [1] [QUIT] 19 [DATA] 11 [,] 2 [DATA]	n= 1. 11,2DATA n= 3.
(x, y)	[SET UP] [4] [2] [QUIT] 19 [,] 67 [DATA] 11[,] 26 [,] 2 [DATA]	n= 1. 11,26,2DATA n= 3.

Data set		
No.	x	y
1	19	67
2	11	26
3	11	26

- If you want to enter weighted data, press [,] after the numerical value(s) of x (and y if applicable), then key in the number of times you wish to repeat the entry.

Data Entry and Correction

Data correction

The calculator does not store the numbers representing statistical data exactly as you enter them, but combines them after each entry into the statistics registers (i.e. $\bar{x}$, Σx, sx, n, etc.). This allows you to enter an almost unlimited number of data samples, but means that you cannot go back through the individual entries and correct data.

STAT	Operation
x	19 [CD]
x with weight	11 [,] 2 [CD]
(x, y)	19 [,] 67 [CD]
(x, y) with weight	11 [,] 26 [,] 2 [CD]

You can correct data in the same way as entering them, except that you have to press [CD] instead of [DATA]. This causes the calculator to subtract the number of samples deleted from the n register and the appropriate sums of samples from the Σx and Σy registers then recalculate the results.

You can also use the weighted data entry procedure to subtract numbers more than once.

EXAMPLE

Subtract (19,67) from the above two-variable statistics.

1. Enter all data. (Refer to the key operations in the data entry table.)
   - The display confirms that you have entered three samples (n = 3).

```
n=              1.
11,26,2DATA
n=              3.
```

2. Press 19 [,] 67 [CD].
   - The calculator now only holds two samples of data, both of which are (11,26).

```
n=              3.
19,67CD
n=              2.
```

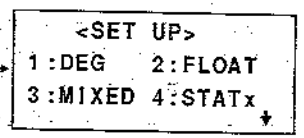
One-Variable Statistics

You can obtain $\bar{x}$, sx, σx, Σx, Σx^2 and n in one-variable statistics mode.

Entering one-variable data

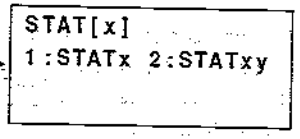
Select STATx in the SET UP menu, then enter your new data set as follows.

1. Key in a number from the data set.
2. Press [DATA].



You can enter weighted one-variable data as follows.

1. Key in a number from the data set.
2. Press [,].
3. Key in the number of samples for this entry.
4. Press [DATA].



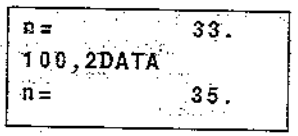
- Statistical results are obtained through the STAT menu after all data has been entered.

Enter the following test scores for 35 students as one-variable data (x).

Entry no.	1	2	3	4	5	6	7	8
Test score	30	40	50	60	70	80	90	100
No. of students	1	1	4	5	8	9	5	2

1. Press [CL] [SET UP] [4] [1] [QUIT].
   - One-variable mode is selected and all previous data is cleared.

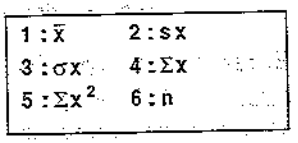
2. Press 30 [DATA] 40 [DATA] 50 [,] 4 [DATA] 60 [,] 5 [DATA] 70 [,] 8 [DATA] 80 [,] 9 [DATA] 90 [,] 5 [DATA] 100 [,] 2 [DATA].
   - Check on the display that you have entered all 35 data items (n = 35).



One-Variable Statistics

Analyzing statistics

After entering your one-variable data set, you can find $\bar{x}$, sx, σx, Σx and Σx^2 by pressing [STAT] and a number from [1] to [5].



The following table shows the functions available and the results that would be obtained from the data set on the previous page.

Function	Key operations	Result
Mean value of samples ($\bar{x}$)	[STAT] [1] [ENTER]	x̄= 71.42857143
Sample standard deviation (sx)	[STAT] [2] [ENTER]	sx= 16.47508942
Population standard deviation (σx)	[STAT] [3] [ENTER]	σx= 16.23802542
Sum of samples (Σx)	[STAT] [4] [ENTER]	Σx= 2500.
Sum of squares of samples (Σx^2)	[STAT] [5] [ENTER]	Σx^2= 187800.

- sx is an estimate of the standard deviation of a population from a sample set of data comprising *part* of that population.
- σx is the standard deviation of a population calculated from *all* the data for that population.

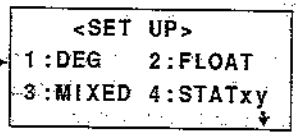
Two-Variable Statistics

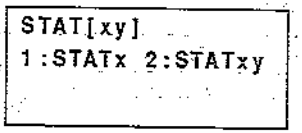
In two-variable statistics mode you can find $\bar{y}$, sy, σy, Σy, Σy^2 and Σxy as well as the one-variable functions described on the previous page.

Entering two-variable data

Select STATxy in the SET UP menu, then enter your new data set as follows.

1. Key in a value for x from the data set.
2. Press [,].
3. Key in a value for y from the data set.
4. Press [DATA].





You can enter weighted two-variable data as follows.

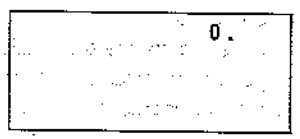
1. Key in a value for x from the data set.
2. Press [,].
3. Key in a value for y from the data set.
4. Press [,].
5. Key in the number of samples for this entry.
6. Press [DATA].

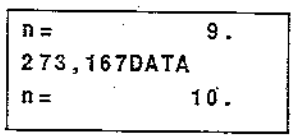
- Two-variable statistical results are obtained through the STAT menu after all data has been entered.

Enter the following two-variable data set representing the relationship between numbers of elementary schools and junior high schools.

Entry no.	1	2	3	4	5	6	7	8	9	10
No. of lementary schools	274	529	345	843	1480	422	194	686	799	273
No. of Junior high school	120	229	146	388	857	196	61	278	369	167

1. Press [CL] [SET UP] [4] [2] [QUIT].
   - Two-variable mode is selected and all previous data is cleared.
2. Press 274 [,] 120 [DATA] 529 [,] 229 [DATA] ... 799 [,] 369 [DATA] 273 [,] 167 [DATA].
   - Check on the display that you have entered all 10 data items (n = 10).

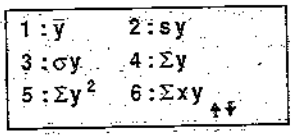




Two-Variable Statistics

Analyzing statistics

After entering your two-variable data set, you can find $\bar{y}$, sy, σy, Σy, Σy^2 and Σxy as well as the one-variable statistics using [STAT] [▼] and a number from [1] to [6].



The following table shows the statistical functions of y that can be obtained from the data set on the previous page.

Function	Key operations	Result
Mean value of samples ($\bar{y}$)	[STAT] [▼] [1] [ENTER]	$\bar{y}$= 281.1
Sample standard deviation (sy)	[STAT] [▼] [2] [ENTER]	sy= 227.6568812
Population standard deviation (σy)	[STAT] [▼] [3] [ENTER]	σy= 215.9742809
Sum of samples (Σy)	[STAT] [▼] [4] [ENTER]	Σy= 2811.
Sum of squares of samples (Σy^2)	[STAT] [▼] [5] [ENTER]	Σy^2= 1256621.
Sum of products of samples (Σxy)	[STAT] [▼] [6] [ENTER]	Σxy= 2425511.

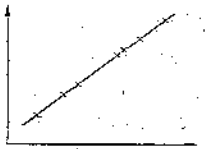
- You can analyze x-variable data using the one-variable statistics functions described above. (☞ p. 55)
- sy is an estimate of the standard deviation of a population from a sample set of data comprising *part* of that population.
- σy is the standard deviation of a population calculated from *all* the data for that population.

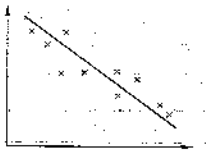
Two-Variable Statistics

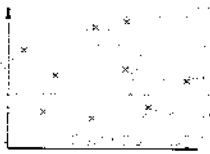
Linear regression

In linear regression the correlation coefficient r describes the quantitative relationship between the two variables x and y, providing a measure of the "goodness of fit" to a straight line for a particular sample.

A straight line is expressed mathematically by a linear equation of the form y = a + bx. The point at which the line crosses the y axis is known as the intercept (a). The slope of the line is called the gradient (b).

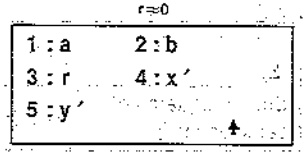






The following table shows the regression operations that can be performed on the above two-variable data set. x′ is the estimated number of elementary schools (x) assuming the number of junior high schools (y) is 500, while y′ is the estimated number of junior high schools when the number of elementary schools is 2000.

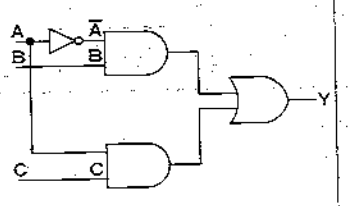
Use [STAT] [▼] [▼] and a number from [1] to [5] to perform the required regression operation.

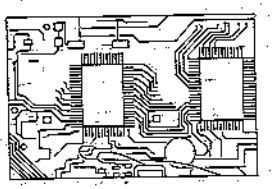


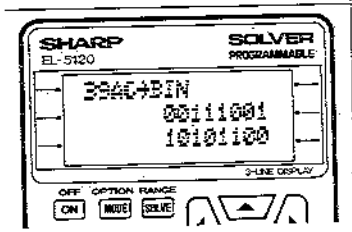
Function	Operation	Result
Intercept (a)	[STAT] [▼] [▼] [1] [ENTER]	a = −55.73076748
Gradient (b)	[STAT] [▼] [▼] [2] [ENTER]	b = 0.576271629
Correlation coefficient (r)	[STAT] [▼] [▼] [3] [ENTER]	r = 0.983215286
Estimated value of x′ (for y = 500)	500 [STAT] [▼] [▼] [4]	500x′ 964.3555903
Estimated value of y′ (for x = 2000)	2000 [STAT] [▼] [▼] [5]	2000y′ 1096.812492

CHAPTER 6:

NUMBER BASE OPERATION







x	1	1	0	0
y	1	0	1	0
x OR y	1	1	1	0

Truth table of OR

NBASE Mode

NBASE mode lets you perform calculations using the four basic arithmetic functions and logical operations in binary (base 2), octal (base 8), decimal (base 10) and hexadecimal (base 16) modes.

Press [MODE] [2] to select NBASE mode. In binary mode, the only active number keys are 0 and 1. In octal mode, the numbers 0–7 are active. In decimal mode 0–9 are active. In hexadecimal mode, the numbers 0–9 and the letters A–F represent the numbers 0–15. There is no need to press [ALPHA] to use letters in hexadecimal mode.

```
NBASE DEC MODE
                0.
```

The following table cross-references numbers expressed in the different number bases.

DEC(10)	0	1	2	3	4	5	6	7	8
BIN(2)	0	1	10	11	100	101	110	111	1000
OCT(8)	0	1	2	3	4	5	6	7	10
HEX(16)	0	1	2	3	4	5	6	7	8
DEC(10)	9	10	11	12	13	14	15	16	...
BIN(2)	1001	1010	1011	1100	1101	1110	1111	10000	...
OCT(8)	11	12	13	14	15	16	17	20	...
HEX(16)	9	A	B	C	D	E	F	10	...

Only integer values can be represented in hexadecimal, octal and binary notation. The decimal point key [•] is ignored by the calculator and exponents are not active.

The maximum value of a number is limited to 10 digits for hexadecimal and octal modes and 16 digits for binary mode. (☞ p. APP-14) Negative numbers are represented in 2's complement notation (the complement of the number plus 1).

NBASE Mode

Selecting bases

After entering NBASE mode, press [MATH] to select the desired number base.

```
1 :→HEX   2 :→DEC
3 :→OCT   4 :→BIN
                  ↓
```

- Press [1], [2], [3] or [4] to select hexadecimal, decimal, octal or binary modes, respectively.
- The calculator remembers this base until you select another base or convert numbers.
- To leave the menu and return to the previous screen, press [QUIT].

Converting numbers

You can convert a number in the display to the selected base (as long as the number does not exceed the calculation range of the base) by selecting a new base as above.

EXAMPLE

Convert 214 (DEC) to hexadecimal then to binary.

1. Press [CL] [MATH] [2] 214 [MATH] [1].

```
                0.
214→HEX
    00000000D6
```

   - 214 (DEC) is converted to D6 (HEX).
   - The number base also changed to hexadecimal.
   - The displayed result will have the maximum number of digits allowed for the selected number base.

2. Press [MATH] [4].

```
00000000D6→BIN
    00000000
    11010110
```

   - D6 (HEX) is now converted to 11010110 (BIN).
   - The calculator is now in binary mode.

Logical Operations

The calculator can perform six logical operations (AND, OR, NOT, NEG, XOR and XNOR) in NBASE mode.

Logical menu display

After entering NBASE mode, press [MATH] [▼] to call the logical menu.

- Press [1], [2], [3], [4], [5] or [6] to select AND, OR, NOT, NEG, XOR or XNOR, respectively.
- To exit the menu and return to the previous screen, press [QUIT].

```
1:AND   2:OR
3:NOT   4:NEG
5:XOR   6:XNOR
```

AND and OR operations

The following table shows the key operations and truth table for AND and OR. Key in the logical operation between the two operands.

x	1	1	0	0	Key operations
y	1	0	1	0	
x AND y	1	0	0	0	1100 [MATH] [▼] [1] 1010 [ENTER]
x OR y	1	1	1	0	1100 [MATH] [▼] [2] 1010 [ENTER]

Logical Operations

NOT and NEG operations

Because the maximum number of digits is 16, the results of NOT and NEG operations will be displayed as in the following table. Press the logical operation key before the operand.

x	1 0 1 0 1 0	Key operations
NOT x	1 1 1 1 1 1 1 1 1 1 0 1 0 1 0 1	[MATH] [▼] [3] 101010 [ENTER]
NEG x	1 1 1 1 1 1 1 1 1 1 0 1 0 1 1 0	[MATH] [▼] [4] 101010 [ENTER]

XOR and XNOR operations

Since XNOR is simply NOT XOR, the results of these operations are as shown in the following table.
Press the logical operation key between the two operands.

x	1 1 0 0	Key operations
y	1 0 1 0	
x XOR y	0 1 1 0	1100 [MATH] [▼] [5] 1010 [ENTER]
x XNOR y	1 1 1 1 1 1 1 1 1 1 1 1 0 0 1 1	1100 [MATH] [▼] [6] 1010 [ENTER]

Logical Operations

Logical operations in OCT, DEC and HEX formats

You can perform all six logical operations – AND, OR, NOT, NEG, XOR and XNOR – in octal, decimal and hexadecimal formats as well as in binary format.
The calculator automatically converts the numbers you enter to binary notation internally and performs the operation. It then converts the result back to the format you are using and displays the final result.

EXAMPLE

Find C AND 9 in HEX format?

1. Press [CL] [MATH] [1].
   - You are now in hexadecimal format.

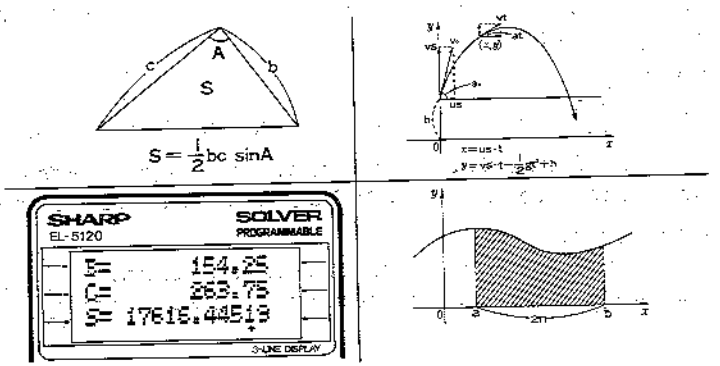
```
        00000000
→HEX
     0000000000
```

2. Press C [MATH] [▼] [1] 9 [ENTER].
   - The calculator performs the operation 1100 (BIN) AND 1001 (BIN) internally.

```
     0000000000
C AND 9=
     0000000008
```


CHAPTER 7:

SOLVING EQUATIONS



Calculation Methods

There are three ways to calculate an unknown variable: using the expression solver, integration and solver functions.

The following table shows when to use each method.

Method	Description	Example
Expression solver	Solves an equation of the form *Unknown variable* = *Expression* The *Expression* must not contain the *Unknown variable*.	$y = Ax^3 - Bx + C$ where y is the *Unknown variable* and different values can be defined for A, B, C and x.
Integration	Finds the area under a curve between two lines x = a and x = b.	$\int_a^b x^2 + Cx - D$
Solver	Finds any *Unknown variable* in any equation.	$\frac{A^3}{B} = 3C - D$ where A, B, C or D can be the *Unknown variable* and different values can be defined for the other variables.

Calculation rules

The expression solver function uses substitution, the integration function uses Simpson's rule and the solver function uses Newton's method to find unknown variables.

Simpson's rule:

$$\int_a^b f(x)dx \approx \frac{b-a}{3N}[f(x_0) + 4f(x_1) + 2f(x_2) + \ldots + 2f(X_{N-2}) + 4f(x_{N-1}) + f(x_N)]$$

where the distance along the x-axis between the integration limits a and b is partitioned into N (N = 2n) increments of equal width (b – a)/N.

Newton's method:

Compares the right-hand and left-hand sides of an equation interactively by substituting numbers within the calculator's range.

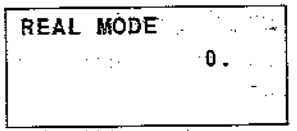
Calculation Methods

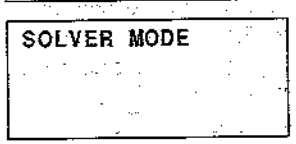
Note: The calculator may not be able to find the solution for certain equations. The answer given by the solver function may, in certain cases, differ from the real answer. (☞ p. APP-8, APP-9)

Selecting the mode

The expression solver function and the integration function are performed in REAL mode while the solver function is performed in SOLVER mode.

To enter REAL mode, press [MODE] [1].
To enter SOLVER mode, press [MODE] [3].





Variables in an equation

Values set for global variables will not be cleared even if you change the operating mode.

Values set for local variables used in the expression solver or numeric integration functions are reset to 0 if you switch to another mode and return to REAL mode.

Values set for local variables used in the solver function are retained if you switch to another mode and return to SOLVER mode.

Whichever mode you are in, the names and values of all local variables will be cleared if you press [CA].

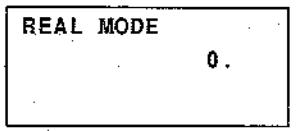
You can save local variables, along with the equation in which they are used, in the EQTN FILE in REAL mode or the SOLVER FILE in SOLVER mode. (☞ p. 81)

For more information about variables, see "Using Memories". (☞ p. 29)

Expression Solver Function

The expression solver function allows you to find different solutions quickly using different sets of values in the same algebraic equation or expression.

Press [MODE] [1] to enter REAL mode.

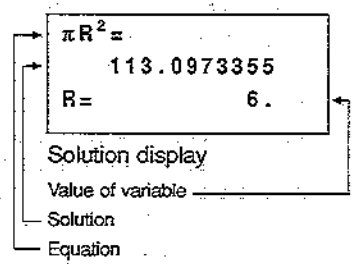


Entering and solving an equation

The expression solver function is used as follows.

1. Enter an equation, using variable names.
2. Press [fx = ?] to call the display for entering and editing variables.
3. Enter the values of the variables.
4. Press [SOLVE].

- In the expression solver function, the equation used must be of the form *Solution* (i.e: the *unknown variable*) = *Expression* or *Expression* = *Solution* (e.g. $S = \pi R^2$, $100 - 100C/P = M$).
- You can use both global and local variables in your equation, but only the local variables will be stored if you save the equation.
- Pressing [fx = ?] while or after entering an equation calls the display for entering and editing variables.
- After entering the values for the variables, press [SOLVE] to find the answer.
- The answer calculated from your expression solver equation will be stored in "last answer" memory as for a normal calculation.



Expression Solver Function

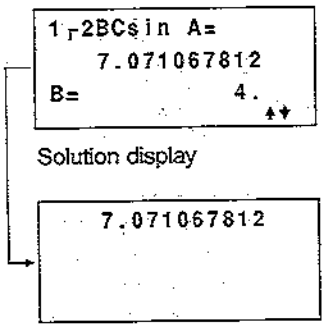
- You do not have to enter a complete equation (*Solution* = *Expression* or vice versa) to be able to solve it. You need enter only the side of the equation that contains the variables (*Expression*).

Editing an equation

If you wish to edit your equation, you can do so in the normal way in REAL mode.

If you are in the display for entering and editing variables, press [QUIT] to return to the normal display.

If you press [QUIT], the answer you found in the expression solver function will appear on the display. You can return to the equation by pressing any cursor key [◄►].



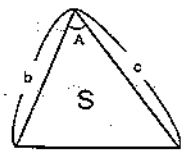
Expression Solver Function

Solving an equation for different variables

EXAMPLE

Find the area $S = \frac{1}{2}bc \sin A$ 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)



$S = \frac{1}{2}bc \sin A$

1. Press [SET UP] [1] [1] [QUIT].
   - Sets the angle unit to DEG.
2. Press 1 [a/b] 2 [B] [C] [sin] [A].
   - The equation is entered in the normal way.
   - There is no need to press [×] between [B] and [C] or [C] and [sin].
   - For all the triangles in this example, side C is 5 units long. You may therefore enter 5 instead of entering the variable C. You would have to enter the multiplication sign after b in this case as b is followed by a numerical multiplicand (5).

```
1┌2BCsin A_
```

3. Press [fx = ?].
   - The calculator automatically calls the display for entering or editing variables and picks out the variables to be edited in alphabetical order.
   - ↓ indicates that there are more variables still to have values assigned later in the equation.

```
1┌2BCsin A=
PRESS [SOLVE]
A=              0.
                  ↓
```

4. Press 90 [ENTER].
   - The calculator picks out the next variable. A value may appear for any variable that has been used before.

```
1┌2BCsin A=
PRESS [SOLVE]
B=              0.
                ↑↓
```


Expression Solver Function

5. Press 3 [ENTER] 5 [ENTER].
   - ↑ on the display indicates that this is the last variable.
   - You can review the value of a variable using [▲].

```
1┌2BCsin A=
PRESS [SOLVE]
C=              5.
                ↑
```

6. Press [▲] [▲] [SOLVE].
   - You do not have to be at the end of the set of variables to press [SOLVE].
   - The answer is displayed in the second line and the variable which was displayed when you pressed [SOLVE] is displayed in the third line.

```
1┌2BCsin A=
                7.5
A=              90.
                  ↓
```

Area of triangle ① is 7.5 square units

7. Press 45.
   - The calculator automatically returns to the display for entering and editing variables.
   - The cursor picks out the variable that was displayed under the answer.
   - If you want to edit variable A, move the cursor until you find it, then edit the value.

```
1┌2BCsin A=

A=45_
                  ↓
```

8. Press [SOLVE].
   - 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.
   - You can skip pressing [ENTER] just before pressing [SOLVE].

```
1┌2BCsin A=
   5.303300859
A=              45.
                  ↓
```

Area of triangle ② is displayed.

9. Press [▼] 4 [SOLVE].
   - Pressing the cursor key recalls the display for entering or editing variables.

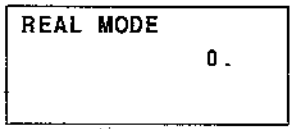
```
1┌2BCsin A=
   7.071067812
B=              4.
                ↑↓
```

Area of triangle ③ is displayed.

Numeric Integration Function

Your calculator can perform integration (finding the area between a curve and the x-axis) using Simpson's rule. (☞ p. 66)

Press [MODE] [1] to enter REAL mode.

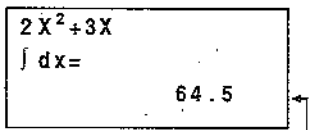


Entering and solving an equation

The integration function is used as follows.

1. Enter an expression with a variable X.
2. Press [∫dx = ?].
3. Enter the integration limits (from a to b) and the number of increments (n).
4. Press [SOLVE].

- The integration expression must be derived from a function of the form.
  $\int_a^b (Expression)dx$
  e.g. $\int_1^4 (2x^2 + 3x)dx$



Solution display

Solution

Equation

- You can use both global and local variables in your function, but only the local variables will be stored when you save the function.
- Pressing [∫dx = ?] while or after entering an equation calls the display for entering or editing the limits and number of increments.
- After entering the limits and the number of increments, press [SOLVE] to find the answer.
- The answer calculated in your integration equation will be stored in "last answer" memory as for a normal calculation.

Numeric Integration Function

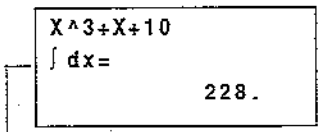
Editing an expression

If you wish to edit your expression, you can do so in the normal way in REAL mode.

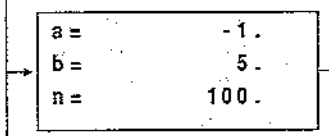
If you are in the solution display, press [QUIT] to return to the display for entering and editing limits or number of increments and press [CL] to return to the normal display. You can return to the expression by pressing any cursor key [▷][◁].

If you are in the display for entering and editing limits or number of increments, press [QUIT] to return to the normal display.

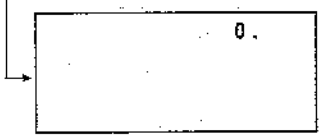
If you press [QUIT] again, the answer you found in the integration function will appear on the display. You can return to the expression by pressing any cursor key [▷][◁].



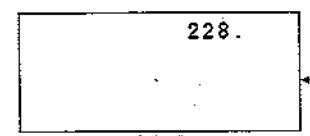
Solution display



After pressing [QUIT]



After pressing [CL]



After pressing [QUIT]

Numeric Integration Function

Solving an equation for different values

EXAMPLE

Solve $\int_{-1}^{5}(x^3 + X + 10)dx$

1. Press [X] [y^x] 3 [+] [X] [+] 10.
   - The equation is entered in the normal way.
   - Any value already stored as X will be ignored in an integral equation.
   - There is no need to enter dx.

```
X^3+X+10_
```

2. Press [∫ dx = ?].
   - The calculator automatically calls the display for entering and editing limits or number of increments.
   - The values of a, b and n have previously been set to 0, 1 and 100, respectively.

```
a=              0.
b=              1.
n=            100.
```

3. Press -1 [ENTER] 5 [ENTER].
   - Sets both the starting and finishing points.
   - Let us take 100 as the number of increments, as in the display.

```
a=             -1.
b=              5.
n=            100.
```

4. Press [SOLVE].
   - COMPUTING! is displayed while calculation is performed.
   - The answer is displayed in the third line.

```
COMPUTING!
```

```
X^3+X+10
∫ dx=
                228.
```


Numeric Integration Function

Important notes

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

1. You can interrupt the calculation by pressing [QUIT].
2. You must select the appropriate angle unit before entering an equation.
3. The calculator uses Simpson's rule to perform integration. For this reason, it may take a long time to find a solution.
4. Because of the nature of Simpson's rule, which provides a best estimate rather than a precise calculation of a given integral, there may in certain cases be a large discrepancy between the real answer and the answer the calculator comes up with.
   If you suspect that the result you have obtained is incorrect, refer to the Appendix. (☞ p. APP-8)

```
COMPUTING!
```

```
BREAK!

PRESS [QUIT]
```

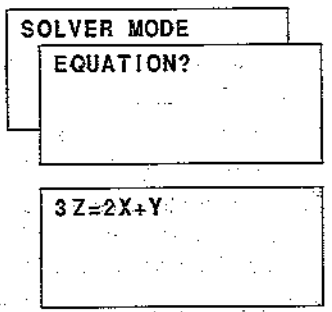
Solver Function

In SOLVER mode, the calculator can find any variable in an equation.

Mode selection

Press [MODE] [3] to select SOLVER mode.

- If no equation has yet been entered in SOLVER mode, EQUATION? appears on the display.
- Otherwise, the last equation you were working with in SOLVER mode will appear when you reselect that mode.

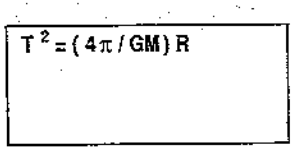


Entering and solving an equation

The solver function is used as follows:

1. Enter both sides of an equation, using variable names.
2. Press [ENTER].
3. Enter the value of the known variables.
4. Move the cursor to the unknown variable.
5. Press [SOLVE].

- The solver function can find any variable anywhere in an equation. It can even solve for a variable that appears several times in an equation.
- You can use both global and local variables in your equation, but only local variables will be stored if you save the equation.



Equation entering display

Solver Function

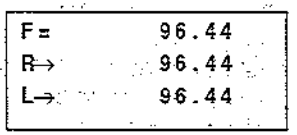
Editing an equation

If you wish to edit your equation in SOLVER mode, you can do so in the same way as in REAL mode.

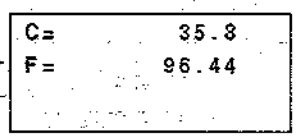
If you are in the solution display, first press [QUIT] to return to the display for entering or editing variables, then return to the equation display by pressing [QUIT] again.

If you wish to clear the old equation and start work with a new equation, press [CL] or [CA].

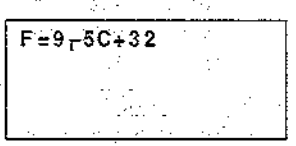
- Pressing [CL] only clears the equation; the names and values of the variables are not cleared.
- Pressing [CA] clears the equation and the names and values of the local variables.
- In both cases, the calculator will ask you to confirm that you really want to clear the equation.



Solution display



After pressing [QUIT]



After pressing [QUIT] again

Solver Function

Solving an equation

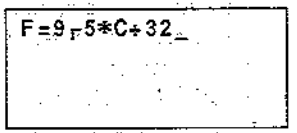
To solve an equation in SOLVER mode, you must enter both its left-hand and its right-hand sides in full.

EXAMPLE

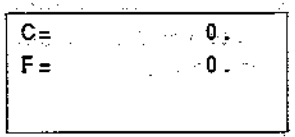
Using the equation below, convert 35.8°C to Fahrenheit (F) and 212°F to Celsius (C).

$$F = \frac{9}{5}C + 32$$

1. Press [F] [=] 9 [a/b] 5 [×] [C] [+] 32.
   - You must enter the whole equation.
   - You may skip pressing [×] since the fraction operation has a higher priority than the implied multiplication operation 5C.

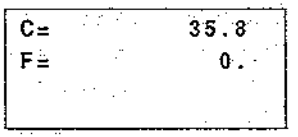


2. Press [ENTER].
   - The calculator automatically calls the display for entering or editing known variables and displays the variables in alphabetical order.
   - If a variable already has a value, the calculator displays that value automatically.
   - The cursor appears at the top left of the display (i.e. on C in this case).

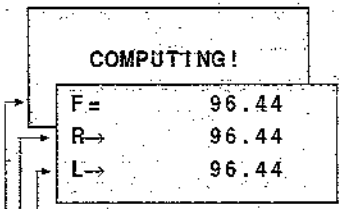


Solver Function

3. Press 35.8 [ENTER].
   - Enters a value for known variable C.
   - The cursor moves on to the next variable.

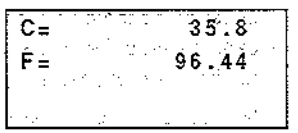


4. Press [SOLVE].
   - The calculator finds the value for the unknown variable which was indicated by the cursor.
   - The value shown on the display for the unknown variable does not have to be set to 0 when you solve the equation. This value is ignored when you press [SOLVE].
   - The answer is displayed on the top line and the values of the left-hand and right-hand sides of the equation appear below.

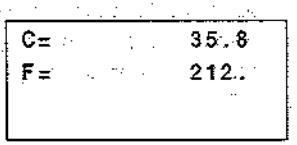


Solution display
- Value of the left-hand side of the equation
- Value of the right-hand side of the equation
- Solution

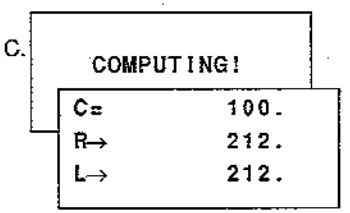
5. Press [QUIT].
   - Returns you to the display for entering or editing variables.
   - The answer you found is now shown for variable F.



6. Press 212 [ENTER].
   - 212 [ENTER] substitutes the value 212 for F.
   - The cursor remains on F as there are no other variables to move forward to.



7. Press [▲] [SOLVE].
   - [▲] moves the cursor to C and [SOLVE] finds the new solution for C.
   - You can find more unknowns using the same equation.

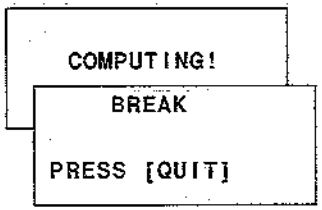


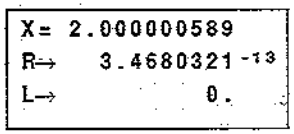
Solver Function

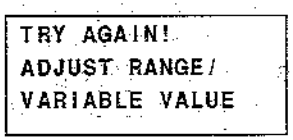
Important notes

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

1. You can interrupt the calculation by pressing [QUIT].
2. You must select the appropriate angle unit before entering an equation.
3. The calculator uses Newton's method to solve equations. Because of this there may be some equations that it fails to solve even though they are in fact soluble. (☞ p. APP-9)
4. The calculator stops calculating when the values it has obtained for the left-hand and right-hand sides of the equation become very close. Thus in certain cases the solution it gives may not be the real answer. (☞ p. APP-10)
5. In certain cases, the calculator may abort a calculation and display the message shown on the right. If this happens, refer to the Appendix. (☞ p. APP-9)





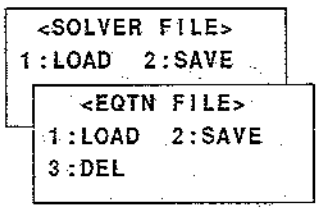


Filing Equations

If you are in REAL mode working with the expression solver function or integration function, you can store your equations in EQTN FILE. If you are in SOLVER mode using the solver function, your equations can be stored in SOLVER FILE. Equations are saved, loaded or deleted in the same way in both modes.

Pressing [FILE] in REAL or SOLVER mode calls the EQTN FILE or SOLVER FILE menu, respectively.

- Press [1], [2] or [3] to select the equation to be loaded, saved or deleted, respectively.

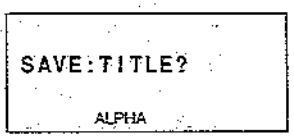


FILE menu

Saving an equation

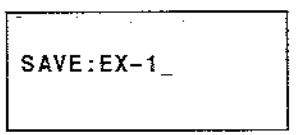
You can save an equation as follows.

1. Press [2] in the FILE menu.
   - The file name display appears asking you to enter a title.
   - The calculator automatically locks ALPHA on to let you enter alphabetical characters easily. To cancel the ALPHA setting, press [ALPHA].



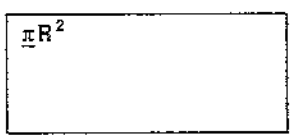
File name display

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 [QUIT].



"EX-1" is entered as the file name.

3. Press [ENTER] after the name entry.
   - The display returns to the display before pressing [FILE].



Filing Equations

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 [1] or [3] in the [FILE] menu to retrieve (load) or delete.
2. Use [▼] or enter the appropriate number to indicate the name of the file you wish to retrieve (or delete) on the display, then press [ENTER].
   - The display asks for confirmation if you are deleting an equation. Press [ENTER] to proceed with deletion or [QUIT] to cancel the operation.
   - If the equation being retrieved contains local variables, their values will be retrieved along with the equation.
   - Any other equation and local variables on the display before the equation was retrieved are cleared.

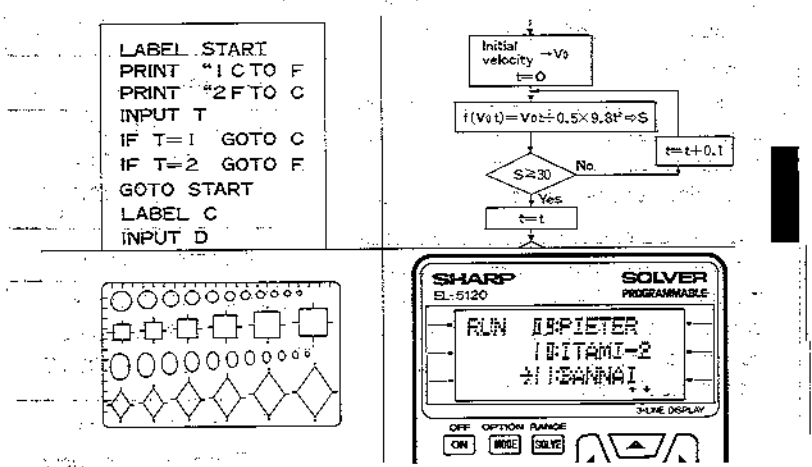
```
DEL → 01:EX-1
      02:AREA-3
      03:CIRCUIT
```

DEL has been selected.

```
TITLE:EX-1
  DEL →[ENTER]
  QUIT→[QUIT]
```


CHAPTER 8:

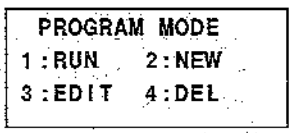
PROGRAMMING



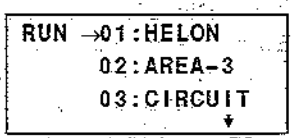
PROGRAM Mode

You can program your calculator to automate both simple and complex calculations. Programs can be used either in REAL mode or in NBASE mode. In REAL mode, you can perform normal mathematical operations and statistical operations. In NBASE mode, you can perform logical operations and calculations using hexadecimal, decimal, octal or binary numbers.

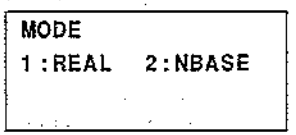
Press [MODE] [4] to select PROGRAM mode. Pressing [1], [2], [3] or [4] then lets you RUN a program, create a NEW program, EDIT a program or DELete a program, respectively.



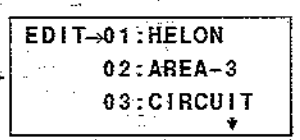
Initial display



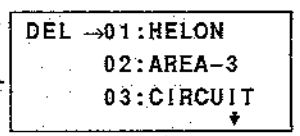
After pressing [1] ※



After pressing [2]



After pressing [3] ※



After pressing [4] ※

※ These displays show example program names.

About programming

This manual does not go into all the details of how to write programs. The information here is intended to help you apply previous programming experience (in BASIC, FORTRAN or another language) to write programs on your calculator. The calculator programming language has similarities to various widely used programming languages.

All conventional computer and calculator programs use one or more fundamental elements, such as input, conditional branching, looping, computation and output.

Your calculator's programming language includes commands that allow you to incorporate all of these fundamental elements into your programs. For a list of commands, see the "Programming Commands" section. (☞ p. 90)

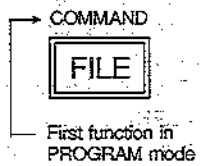
PROGRAM Mode

Note: Commands must be selected from the COMMAND menu. They cannot be typed manually using the ALPHA key.

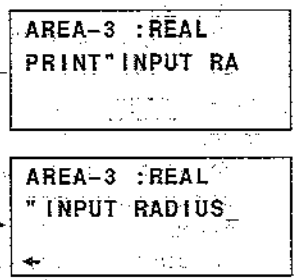
The keys and the display

To allow you to create programs as simply as possible, some of the keys and the display work differently in PROGRAM mode from the way they work in other modes. The differences are as follows.

- The [FILE] function does not work in PROGRAM mode; [COMMAND] becomes the first function.



- While you are in the display for entering a program name, ALPHA mode is locked on for convenience.
- A single line of a program can hold 159 characters. All commands count as one character. As you key in a line, the displayed text scrolls to the left. Lines do not wrap in PROGRAM mode.



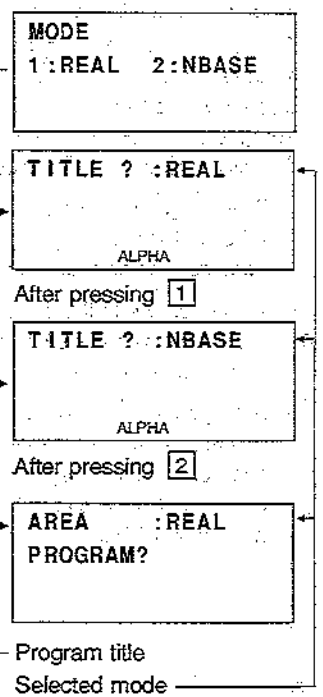
Entering: PRINT " INPUT RADIUS

Creating a New Program

Whenever you create a program, the calculator automatically stores the whole program under its name in a particular memory. You do not have to worry about saving the program.

Get ready to enter a new program as follows.

1. After entering PROGRAM mode, press [2] to create a new program.
   - In this display, press [1] to select REAL mode or [2] to select NBASE mode.
2. The display for entering a program name (title) appears after you have selected the mode.
   - The calculator automatically locks ALPHA on so that you can enter the title in alphabetic characters. You can cancel the ALPHA setting by pressing [ALPHA].
   - The program name can have up to seven characters.
3. Press [ENTER] to enter the program name.
   - You are now ready to start entering a program for the mode you have selected.
   - You can enter the calculator's regular functions as commands. You can also use the additional programming commands in the [COMMAND] menu.



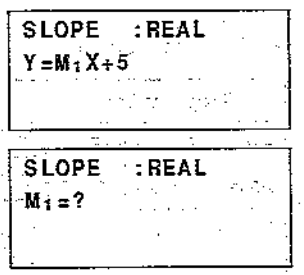
Creating a New Program

About variables

In PROGRAM mode, global and local variables are treated differently.

- The characters 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 on 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. The names of local variables consist of a letter for the first character and a number for the second character. Local variables exist only in a particular program.

If a line in your program contains an equation such as $Y = M_1X + 5$, it sets the global variable Y equal to $(M_1 * X) + 5$. If the local variable M_1 is not defined earlier in the program, the calculator prompts you with $M_1 = ?$ to enter a value for M_1 when the program is run. The program takes the value for the global variable X from its own X memory.



Creating a New Program

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

EXAMPLE

Create a simple program that asks you the base (B_1) and height (H_1) of a triangle and then calculates and displays the area (A). Calculate the area of a triangle with base 4 units and height 3 units.

1. Get ready to create a program.

Procedure	Key operations	Display
Select PROG mode.	MODE 4	
Select NEW program.	2	
Select REAL mode.	1	AREA :REAL PROGRAM?
Key in program name.	AREA	
Enter program name.	ENTER	

2. Enter the program.

Program line	Key operations
PRINT" B1 = BASE	COMMAND 2 [B]1[=][B][A][S][E] ENTER
PRINT" H1 = HEIGHT	COMMAND 2 [H]1[=][H][E][I][G][H][T] ENTER
A = 1/2 B_1H_1	[A][=]1 a/b 2[VAR]B1 ENTER ENTER [VAR] ▼ H1 ENTER ENTER ENTER
PRINT" AREA	COMMAND 2 [A][R][E][A] ENTER
PRINT A	COMMAND 1 [A] ENTER

Creating a New Program

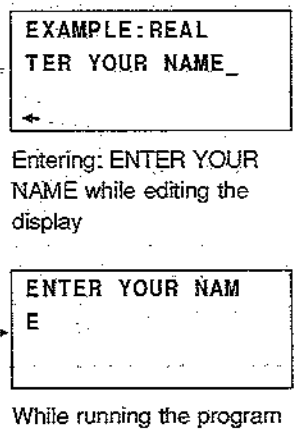
3. RUN the program.

Procedure	Key operations	Display
Return to the PROGRAM mode display.	QUIT	
Select RUN.	1 ENTER	AREA A=
Enter 4 for the base.	4 ENTER	6.
Enter 3 for the height.	3 ENTER	

- The program automatically prompts you to enter the unknown local variables.

Notes on creating programs

1. When a program is running, text displayed by the program (using the PRINT" command) will wrap to the next line of the display if necessary.
2. You can only enter one command per line (except for the special case of IF ... GOTO, ☞ p. 92).



Entering: ENTER YOUR NAME while editing the display

While running the program

Programming Commands

This section describes all the commands that are available in program mode. It does not include keyboard commands or MATH menu commands.

Input and display commands

Press [COMMAND] to call the first page of the COMMAND menu.

- Press [1], [2], [3], [4], [5] or [6] to select PRINT, PRINT", INPUT, WAIT, REM or END, respectively.

```
1:PRINT 2:PRINT"
3:INPUT 4:WAIT
5:REM   6:END
```

Command	Description	Examples
PRINT <variable>	Prints the value of a variable. The display format is determined by the SET UP menu.	`PRINT A` `PRINT B;`
PRINT" <any text>	Prints the text listed after the quotation mark. If the text exceeds 42 characters only the last 42 characters will be displayed.	`PRINT"SHARP`
INPUT <variable>	Stops the program and prompts you with "<variable>=" to enter a value for a variable.	`INPUT A` `INPUT B;`

Programming Commands

Command	Description	Examples

WAIT <number>	Pauses the program for a specified number of seconds. The maximum wait time is 255 seconds. If no wait time is specified, the program pauses until you press any key. The BUSY indicator stays on while the program is waiting.	`WAIT 5`
		`WAIT FF(HEX)`
		`WAIT 1010(BIN)`

REM <any text>	Inserts a remark, which has no effect on the program operation but allows you to document your programs. Excessive use of this command uses up considerable amounts of memory.	`REM TIME TABLE`
END	Terminates the program. END is not required to end a program. If no END command is included, the last answer calculated will be displayed upon completion of the program. END can also be used within the program to terminate it after various different branches, subroutines etc. have been executed. You can include several END commands in a program.	`END`

Programming Commands

Branches, subroutines etc.

Press [COMMAND] [▼] to call the second page of the COMMAND menu.

- Press [1], [2], [3], [4], [5] or [6] to select LABEL, CLRT, IF, GOTO, GOSUB or RETURN, respectively.

```
1:LABEL 2:CLRT
3:IF    4:GOTO
5:GOSUB 6:RETURN
                ↑↓
```

Command	Description	Examples
LABEL <any text>	Marks the destination point for a branch statement (GOTO or GOSUB). Each label has a seven-character limit and must be unique (i.e. you cannot use the same label more than once in the same program). Up to 20 different labels can be used in a single program.	`LABEL LOOP1` `LABEL LOOP2`
CLRT	Clear the text displayed on the screen.	`CLRT`
IF <condition> GOTO <label>	Conditional branches begin with an IF command; this is followed (in the same program line) by a condition and then a GOTO command. GOTO is the only command that can follow an IF statement. You can enter a space ([SPACE]) before GOTO to improve legibility.	`IF B1=1GOTO LOOP1`

Programming Commands

Command	Description	Examples
GOTO <label>	Causes the program to jump to a given label (text specified by a LABEL command). A GOTO statement must have a corresponding LABEL to mark its destination.	`GOTO LOOP2`
GOSUB <label>	Calls the subroutine beginning with a given label (text specified by a LABEL command). A GOSUB statement must have a corresponding LABEL to mark the beginning of the subroutine and a corresponding RETURN command to mark the end of the subroutine. Subroutines can be nested up to ten levels deep.	`GOSUB PART1`
RETURN	Ends a subroutine. The program resumes operation at the line following the GOSUB statement that called the subroutine.	`RETURN`

Programming Commands

Equality and inequalities

These expressions are used to form the conditions used with the IF command. They are the basis for looping and conditional branching in programs.

"Equal to" [=] can also be used as a command to change the value of a variable.

Press [COMMAND] [▼] [▼] to call the third page of the COMMAND menu.

- Press [1], [2], [3], [4], [5] or [6] to select =, <, <=, >=, > or ≠, respectively. The = expression can also be entered simply by pressing [=].

```
1:=        2:<
3:<=       4:>=
5:>        6:≠
                ↑↓
```

Expression	Description	Examples
=	Equal to. This function is also used as a command to assign a new value to a variable, e.g. when incrementing or decrementing a value.	`IF B=0GOTO ZERO` `A=A+1`
<	Less than.	`IF B<0GOTO NGTV`
<=	Less than or equal to.	`IF B₁<=0GOTO CALC`
>=	Greater than or equal to.	`IF B>=0GOTO RECALC`
>	Greater than.	`IF B₁>0GOTO PSTV`
≠	Not equal to.	`IF A≠BGOTO DIF`

Programming Commands

Statistical commands

In PROGRAM mode, statistical commands are only available when REAL is selected. The statistical command menu cannot be called when NBASE is selected.

Press [COMMAND] [▼] [▼] [▼] to call the fourth page of the COMMAND menu.

- Press [1], [2] or [3] to select DATA, STATx or STATxy, respectively.

```
1:DATA   2:STATx
3:STATxy
```

Command	Description	Examples

DATA <x>
DATA <x, weight>
DATA <x, y>
DATA <x, y, weight>
	Enters new statistical data. The data format must be consistent with the statistics mode selected (one-variable or two-variable). (☞ p.49) A statistical data set entered in PROGRAM mode can be accessed later for use with STAT functions.	`DATA 5.23`
		`DATA 25,2`
		`DATA 72,175`
		`DATA 9,96,3`

STATx	Selects one-variable statistics mode.	`STATx`
STATxy	Selects two-variable statistics mode.	`STATxy`

- When you use the STATx or STATxy command, the calculator erases all data previously stored in the STAT function.

Editing a Program

Press [3] in PROGRAM mode to enter EDIT mode. Select the program you wish to edit and press [ENTER].

- If you want to add lines to your program, press [INS] first to avoid losing lines or text that you want to keep.
- Remember that you can only enter one command per line except in the special case of IF ... GOTO (☞ p.92). Do not try to add extra commands to existing lines.
- The line you are editing is not changed in the program until you press [▼], [▲] or [ENTER]. If you decide not to change a particular program line as you are editing it, press [QUIT].
- If you do want to save the changes you have made to the current line, be sure to press [▼], [▲] or [ENTER] before pressing [QUIT] to return to the PROGRAM mode display.
- To clear an entire line of a program, press [CL]. Any blank lines left between the lines of a program will be ignored when the program is run.
- Note carefully the difference between [CL] and the backspace key [BS]. [BS] deletes the character you have just entered (the character preceding the cursor position) and is useful for correcting typing mistakes.
- To delete an entire program, press [CA].
- You can change the name of a program by overwriting it.

```
EXAMPLE:REAL
B=B÷1
_
```

After pressing [B] [=] [B] [÷] 1 [ENTER]

```
EXAMPLE:REAL
_
```

After pressing [▲] [CL]

```
EXAMPLE:REAL
B=B÷1
```

The cleared text returns if [QUIT] is pressed before the change is entered.

Error Messages

The calculator displays an error message if a program encounters a problem. The error message lets you know what the problem is and the calculator lets you jump to 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.

```
– ERROR 01 –
▶SYNTAX
```

Error display for wrong syntax

To jump to the faulty line, press [▶] or [◀]. To return to the program menu, press [CL].

You can press [QUIT] to stop your program at any time while it is running. This is necessary if your program enters an endless loop. If you then press [▶] or [◀], the cursor appears at the last line of the program that was executed.

```
INPUT A
B= π2²*A
PRINT B
```

After pressing [▶] or [◀]

If you press [QUIT] again, the initial display reappears.

```
PROGRAM MODE
1:RUN  2:NEW
3:EDIT 4:DEL
```

After pressing [CL]

For a list of error messages, see the Appendix. (☞ p. APP-6)

```
BREAK!

PRESS [QUIT]
```

After pressing [QUIT] while running a program.

Example Programs

These examples demonstrate different programming modes, program input, loops and conditional branches. Try running them to gain some experience programming the calculator.

Some like it hot

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

1. Press [MODE] [4] [2] [1] TEMP [ALPHA] [ENTER].
   - Allows you to create a new REAL mode program called "TEMP".

```
TEMP     :REAL
PROGRAM?
```

2. Enter the following program.

Program line	Key operations
LABEL START	[COMMAND] [▼] [1] [S][T][A][R][T] [ENTER]
PRINT" (1) C TO F	[COMMAND] [2] [(] [1] [)] [SPACE][C][SPACE][T][O][SPACE][F] [ENTER]
PRINT" (2) F TO C	[COMMAND] [2] [(] [2] [)] [SPACE][F][SPACE][T][O][SPACE][C] [ENTER]
INPUT C_1	[COMMAND] [3] [VAR]C1 [ENTER] [ENTER] [ENTER]
IF C_1=1 GOTO CTOF	[COMMAND] [▼] [3] [VAR] [ENTER] [=] 1[SPACE] [COMMAND] [▼] [4] [C][T][O][F] [ENTER]
IF C_1=2 GOTO FTOC	[COMMAND] [▼] [3] [VAR] [ENTER] [=] 2[SPACE] [COMMAND] [▼] [4] [F][T][O][C] [ENTER]
GOTO START	[COMMAND] [▼] [4] [S][T][A][R][T] [ENTER]

(Program continues)

Example Programs

Program line	Key operations
LABEL CTOF	[COMMAND] [▼] [1] [C][T][O][F] [ENTER]
F=(9/5)C_0+32	[F][=] [(] 9 [÷] 5 [)] [VAR] [▼] C0 [ENTER] [ENTER] [+] 32 [ENTER]
PRINT F	[COMMAND] [1] [F] [ENTER]
END	[COMMAND] [6] [ENTER]
LABEL FTOC	[COMMAND] [▼] [1] [F][T][O][C] [ENTER]
C=(5/9)*(F_0–32)	[C][=] [(] 5 [÷] 9 [)] [×] [(] [VAR] [▼] F0 [ENTER] [ENTER] [–] 32 [)] [ENTER]
PRINT C	[COMMAND] [1] [C] [ENTER]
END	[COMMAND] [6] [ENTER]

3. Press [QUIT] [1], select the program "TEMP" and press [ENTER].
   - The program prompts you to choose which type of conversion you want. It then prompts you to enter the temperature and displays the result.

Going straight

This is a simple program in REAL mode which uses STAT functions. It asks you to input two-variable data and then examines the correlation coefficient (*r*).

1. Press [MODE] [4] [2] [1] STAT [ENTER].
   - Allows you to create a new REAL mode program called "STAT".

```
STAT     :REAL
PROGRAM?
```

Example Programs

2. Enter the following program.

Program line	Key operations
STATxy	COMMAND ▼ ▼ ▼ 3 ENTER
GOSUB ENTRY	COMMAND ▼ 5 [E][N][T][R][Y] ENTER
R=r	[R][=][STAT] ▼ ▼ 3 ENTER
R=ABS R	[R][=] MATH 1 [R] ENTER
IF R=1 GOTO STRA1	COMMAND ▼ 3 [R][=]1 COMMAND ▼ 4 [S][T][R][A]1 ENTER
IF R>0.95 GOTO STRA2	COMMAND ▼ 3 [R] COMMAND ▼ ▼ 5 0.95 COMMAND ▼ 4 [S][T][R][A]2 ENTER
PRINT" NO RELATIONSHIP	COMMAND 2 [N][O][SPACE][R][E][L][A][T][I][O][N][S][H][I][P] ENTER
END	COMMAND 6 ENTER
LABEL STRA1	COMMAND ▼ 1 [S][T][R][A]1 ENTER
PRINT" STRAIGHT!	COMMAND 2 [S][T][R][A][I][G][H][T] MATH ▼ 1 ENTER
END	COMMAND 6 ENTER
LABEL STRA2	COMMAND ▼ 1 [S][T][R][A]2 ENTER
PRINT" ALMOST STRAIGHT	COMMAND 2 [A][L][M][O][S][T][SPACE][S][T][R][A][I][G][H][T] ENTER
END	COMMAND 6 ENTER
LABEL ENTRY	COMMAND ▼ 1 [E][N][T][R][Y] ENTER
PRINT" ENTER NUMBER OF ENTRIES	COMMAND 2 [E][N][T][E][R][SPACE][N][U][M][B][E][R][SPACE][O][F][SPACE][E][N][T][R][I][E][S] ENTER

(Program continues)

Example Programs

Program line	Key operations
INPUT N	COMMAND 3 [N] ENTER
LABEL LOOP1	COMMAND ▼ 1 [L][O][O][P]1 ENTER
PRINT N	COMMAND 1 [N] ENTER
INPUT X	COMMAND 3 [X] ENTER
INPUT Y	COMMAND 3 [Y] ENTER
W=1	[W][=]1 ENTER
INPUT W	COMMAND 3 [W] ENTER
DATA X, Y, W	COMMAND ▼ ▼ ▼ 1 [X],[Y],[W] ENTER
N=N–1	[N][=][N] – 1 ENTER
IF N>0 GOTO LOOP1	COMMAND ▼ 3 [N] COMMAND ▼ ▼ 5 0 COMMAND ▼ 4 [L][O][O][P]1 ENTER
RETURN	COMMAND ▼ 6 ENTER

3. Press QUIT 1 , select the program "STAT" and press ENTER .
   - The program prompts you to enter the number of entries and then to enter the two-variable statistical data (W = weight).
   - If your data set shows an approximately linear relationship, the correlation coefficient r is close to 1 or –1, the values which represent a straight line.

Example Programs

2B or not 2B

When you write a program in NBASE mode, the conversion functions and logical operations can be used. This is a simple program in NBASE mode that converts a decimal number to binary, octal and hexadecimal formats.

1. Press [MODE] [4] [2] [2] NBASE [ALPHA] [ENTER].
   - Allows you to create a new NBASE mode program named "NBASE".

```
NBASE   :NBASE
PROGRAM?
```

2. Enter the following program.

Program line	Key operations
PRINT" ENTER A	[COMMAND] [2] [E][N][T][E][R][SPACE][A] [ENTER]
PRINT" DECIMAL NUMBER	[COMMAND] [2] [D][E][C][I][M][A][L][SPACE][N][U][M][B][E][R] [ENTER]
INPUT X	[COMMAND] [3] [X] [ENTER]
X → BIN	[X] [MATH] [4] [ENTER]
B_0=X	[VAR]B0 [ENTER] [ENTER] [=][X] [ENTER]
PRINT" → BIN	[COMMAND] [2] [MATH] [4] [ENTER]
PRINT B_0	[COMMAND] [1] [VAR] [ENTER] [ENTER]
WAIT	[COMMAND] [4] [ENTER]
X → OCT	[X] [MATH] [3] [ENTER]
O_0=X	[VAR] [▼] O0 [ENTER] [ENTER] [=][X] [ENTER]
PRINT" → OCT	[COMMAND] [2] [MATH] [3] [ENTER]

(Program continues)

Example Programs

Program line	Key operations
WAIT 0	[COMMAND] [4] 0 [ENTER]
PRINT O_0	[COMMAND] [1] [VAR] [ENTER] [ENTER]
WAIT	[COMMAND] [4] [ENTER]
X → HEX	[X] [MATH] [1] [ENTER]
H_0=X	[VAR] [▼] H0 [ENTER] [ENTER] [=][X] [ENTER]
PRINT" → HEX	[COMMAND] [2] [MATH] [1] [ENTER]
WAIT 0	[COMMAND] [4] 0 [ENTER]
PRINT H_0	[COMMAND] [1] [VAR] [ENTER] [ENTER]

- Note that the program transfers the value of X to variables B_0, O_0 and H_0 before printing. This is done so that the program is documented more clearly.

3. Press [QUIT] [1], 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 octal format, and then to see it in hexadecimal format.

Be careful when using the WAIT command in NBASE mode. Numbers used after the WAIT command are processed according to the current number base, which may be binary, octal, decimal or hexadecimal.

To specify the wait time in decimal format, define a variable (e.g. T = 5) for the wait time and use it in the WAIT command (i.e. WAIT T).

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 can delete old ones.

Delete a program as follows.

1. Press [MODE] [4] to enter PROGRAM mode.
   - If you are already in PROGRAM mode, press [QUIT] to return to the PROGRAM mode display.

```
PROGRAM MODE
1:RUN   2:NEW
3:EDIT  4:DEL
```

2. Press [4].
   - The DEL menu appears. All the programs stored in the calculator are listed.

```
DEL →01:AREA
     02:TEMP
     03:STAT
```

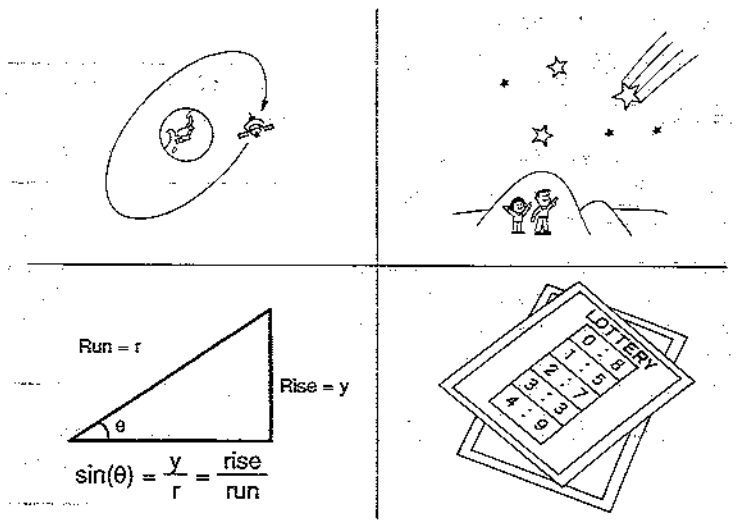
3. Move the cursor to the program you want to delete and press [ENTER].
   - The calculator asks you if you are sure you want to delete the program.
   - Press [ENTER] to delete the program or [QUIT] to cancel the operation.

```
TITLE:AREA
  DEL →[ENTER]
  QUIT→[QUIT]
```

A quick way to delete a program while editing it is to press [CA]. The calculator asks you if you are sure you want to delete the program. Press [ENTER] to delete the program.

CHAPTER 9:

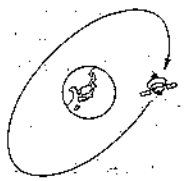
GETTING RESULTS



Physics

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.



EXAMPLE

At what distance from the center of the Earth can geosynchronous orbit occur?

The period of an orbit is described by the equation:

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

where: T = Period of orbit
G = Gravitational constant (6.672×10^{-11} Nm^2kg^{-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. Convert this time to seconds:

1. Press [MODE] [1] [CA] 23.560409 [MATH] [▼] [▼] [1] [×] 60 [x^2] [ENTER].
   - This gives you the value of T.

```
23.560409→DEG
*60^2=
        86164.09
```

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

Two of the numbers used in this equation have only three significant figures after the decimal point. Select the scientific display format with three decimal places, and then select equation edit mode.

3. Press [SET UP] [2] [3] [3] [QUIT].

```
ANS⇒T
        86164.09
           8.616 04
```


Physics

Use the solver function to solve the equation for r.

4. Press [MODE] [3] [CA] [ENTER] [T] [x^2] [=] [(] 4 [π] [x^2] [)] [a/b] [(] [VAR] G 0 [ENTER] [ENTER] [VAR] [▼] M 0 [ENTER] [ENTER] [)] [×] [VAR] [▼] R 0 [ENTER] [ENTER] [y^x] 3.

```
T^2=(4π^2)r(G0M0
)*R0^3
```

5. Check the equation on the display and press [ENTER].
   - The calculator picks out the value of global variable T.

```
T=          8.616 04
G0:         0.000
M0:         0.000
```

6. Press [ENTER] 6.672 [Exp] -11 [ENTER] 5.976 [Exp] 24 [ENTER].
   - Values are entered for G_0 and M_0 and the cursor moves on to variable R_0.

```
G0:         6.672-11
M0:         5.976 24
R0:         0.000
```

7. Press [SOLVE].

```
R0:         4.217 07
R→ 7424250406.
L→ 7424250406.
```

RESULT

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

Physics

Twinkle, twinkle, little star

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:

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

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.)

Rearranging the above equation:

$$\frac{L_2}{L_1} = 10^{0.4(M1\ -\ M2)}$$

Physics

In this case, $M_2 = 2.89$.

Press [MODE] [1] [CA] [SET UP] [2] [1] [QUIT] [10^] [(] 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?

Rearranging the first equation to solve for M_2:

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

In this case, $L_2/L_1 = 0.0003$.
Press 4.8 [−] [(] [log] 0.0003 [÷] 0.4 [)] [ENTER].

```
4.8-(log 0.000
3/0.4)=
    13.60719686
```

RESULT

The absolute magnitude of the second star is about 13.6072.

Physics

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

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

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

Write a program that asks for the original mass and current mass of ^{14}C and tells you how old the specimen is. Then find the half-life of (^{14}C).

1. Press [MODE] [4] [2] [1] DECAY [ENTER].
   - Allows you to create a new REAL mode program called "DECAY".

```
DECAY   :REAL
PROGRAM?
```

2. Enter the following program.

Program line	Key operations
PRINT" ORIGINAL MASS	[COMMAND] [2] [O][R][I][G][I][N][A][L][SPACE][M][A][S][S] [ENTER]

Physics

Program line	Key operations
INPUT M_0	[COMMAND] [3] [VAR]M0 [ENTER] [ENTER] [ENTER]
PRINT" CURRENT MASS	[COMMAND] [2] [C][U][R][R][E][N][T][SPACE][M][A][S][S] [ENTER]
INPUT M_1	[COMMAND] [3] [VAR] [▼] M1 [ENTER] [ENTER] [ENTER]
$T = -(\ln(M_1/M_0))/1.2118E{-}4$	[T][=] [−] [(] [ln] [(] [VAR] [ENTER] [÷] [VAR] [▲] [ENTER] [)] [)] [÷] 1.2118 [Exp] -4 [ENTER]
PRINT T	[COMMAND] [1] [T] [ENTER]
PRINT" YEARS	[COMMAND] [2] [Y][E][A][R][S] [ENTER]
END	[COMMAND] [6] [ENTER]

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

3. Press [QUIT] [1], select the program "DECAY" and press [ENTER] to run the program.

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

4. Press 100 [ENTER] 50 [ENTER] to enter values for M_0 and M_1.

```
T=
    5719.980034
YEARS
```

RESULT

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

Statistics

Chi-squared test

The chi-squared (χ^2) test compares a sample of data with a statistical hypothesis (probability distribution). It is a "goodness of fit" test that is applicable to nominal scale data (discrete functions). The data are tallies of observations in various categories.

In the chi-squared test, observed experimental values are compared to expected values derived from a probability distribution model.

The following value is calculated and compared to a table of critical chi-squared values:

$$\chi^2 = \Sigma \frac{(f_i - F_i)^2}{F_i} \quad \text{or} \quad \Sigma \frac{(\text{Observed no.} - \text{Expected no.})^2}{\text{Expected no.}}$$

where: f_i = Actual no. of observations for category i

F_i = Expected no. of observations for category i based on the statistical distribution model

EXAMPLE

You have been culturing a plant with flowers of types P, Q, R and S. According to Mendel's Laws, the numbers of the different types of flower should conform to the ratio 9:3:3:1. You want to find out whether the flowers you have been culturing conform to Mendel's probability model.

The numbers of the different flowers in your experiment are shown in the following table:

Flower type	P	Q	R	S	Total
Probability ratio	9	3	3	1	16
Expected proportion of flowers	$\frac{9}{16}$	$\frac{3}{16}$	$\frac{3}{16}$	$\frac{1}{16}$	1
Observed no. of flowers	125	40	42	12	219

Statistics

You can compute the expected number of flowers of each type F_i by multiplying the expected proportion for that type by the total number of flowers.

1. Press [MODE] [1] [CA].
2. Press 9 [÷] 16 [×] 219 [STO] P.
   - Stores the expected number of flowers of type P as variable P.

```
                0.
9/16*219⇒P
          123.1875
```

3. Press 3 [÷] 16 [×] 219 [STO] Q [STO] R.
   - Stores the expected number of flowers of types Q and R as variables Q and R.

```
          41.0625
ANS⇒R
          41.0625
```

4. Press 1 [÷] 16 [×] 219 [STO] S.
   - Stores the expected number of flowers of type S as variable S.

```
          41.0625
1/16*219⇒S
          13.6875
```

For each flower type, calculate and enter as data the result of the following expression:

$$\frac{(\text{Observed no.} - \text{Expected no.})^2}{\text{Expected no.}}$$

5. Press [SET UP] [4] [1] [QUIT].
   - Selects STATx mode.

Statistics

6. Press [(] 125 [−] [P] [)] [x^2] [÷]
   [P] [DATA] [(] 40 [−] [Q] [)] [x^2] [÷]
   [Q] [DATA] [(] 42 [−] [R] [)] [x^2] [÷]
   [R] [DATA] [(] 12 [−] [S] [)] [x^2] [÷]
   [S] [DATA]

```
n=                    3.
(12-S)²/SDATA
n=                    4.
```

Chi-squared is the sum of results for the four flower types.

7. Press [STAT] [4] [ENTER].
   - Finds the statistic Σx, i.e. chi-squared.

```
n=                    4.
Σx=
     0.283612379
```

RESULT

Chi-squared is 0.283612379

Compare this calculated chi-squared with critical values from a standard chi-squared table. The number of degrees of freedom is equal to the number of data categories minus 1. The number of categories in this example is 4 (the number of flower types) so the number of degrees of freedom is 3.

The critical value of chi-squared shown in the table (95% level of confidence, 3 degrees of freedom) is 7.81. Since your calculated answer is less than this critical value, your experimental results agree with the hypothesis and suggest that your flowers conform to Mendel's probability model.

Engineering

Angle vs. percentage grade

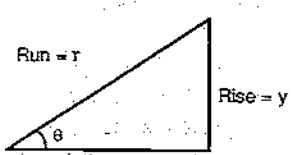
EXAMPLE

You have two friends who are arguing about whose street is the steeper. One found out from the city engineer that his street was built on a 35% grade. The other measured the angle of his street to be 20 degrees.

Which street is steeper?

The problem can be solved by converting either measurement into the terms of the other measurement and then comparing the results.

Let us convert the percentage grade to an angle expressed in degrees.



Grade equals rise over run. Percentage grade is grade times 100. Note that rise over run is the same as the sine of the angle.

The equation is:

$$\sin\ \theta = \frac{y}{r} \quad \text{or} \quad \theta = \sin^{-1}\frac{y}{r}$$

where: y = Rise
r = Run

Press [MODE] [1] [CA] [SET UP] [1] [1] [QUIT] [$\sin^{-1}$] [(] 35 [÷] 100 [)] [ENTER]

- Make sure that DEG is selected.

```
sin⁻¹ (35/100)=

     20.48731511
```

RESULT

The 35% grade can be rounded to a 20.49° angle, which represents the steeper street. Your friends can stop arguing.

Business and Money

Bank interest

The formula for determining the future value of an investment earning a fixed rate of interest is:

$$FV = PV(1+i)^n$$

where: FV = Future value of the investment
PV = Present value of the investment
i = Interest rate over a set period (expressed as a fraction)
n = Number of periods for which the investment accrues interest.

EXAMPLE 1

You invest $5,000 in a 4-year bond that pays 9 percent interest, compounded quarterly. What is its value after 4 years?

1. Press [SET UP] 2 2 2 QUIT .
   - Set the calculator for two decimal places (since dollars can only be calculated to two decimal places).

The total number of periods can be calculated from the number of periods per year (4) and the number of years (4) as follows:

$$n = 4 \text{ years} \times \frac{4 \text{ periods}}{\text{year}}$$

$$i = \frac{9\%}{\text{year}} \times \frac{1 \text{ year}}{4 \text{ periods}}$$

2. Press [P] (1 + [I]) y^x [N] [fx=?]
   - Enters an expression for the expression solver function.

```
P(1+I)^N=
PRESS [SOLVE]
I=          0.00
```


Business and Money

3. Press 0.09 ÷ 4 ENTER 4 × 4 ENTER 5000 ENTER .
   - Substitute numbers (the results of the calculations for n and i and the present value of the investment) as variables N, I and P.
4. Press SOLVE .

```
P(1+I)^N=
PRESS [SOLVE]
P=       5000.00
```

RESULT

The investment will be worth $7138.11 in 4 years.

```
P(1+I)^N=
         7138.11
P=       5000.00
```

EXAMPLE 2

What would the value be if the interest were to be compounded daily?

This time:

$$n = 4 \text{ years} \times \frac{365 \text{ days}}{\text{year}}$$

$$i = \frac{9\%}{365}$$

Using the previous expression, substitute new values for variables N and I.

1. Press ▲ ▲ 0.09 ÷ 365 ENTER 4 × 365 SOLVE .
   - Skip entering 5000 in variable P, since its value has not changed from 5000.

```
P(1+I)^N=
         7166.33
N=       1460.00
```

RESULT

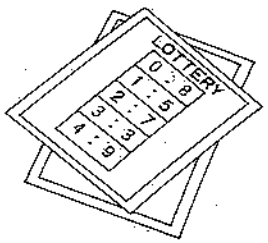
The value (FV) would be 7166.33 if interest was compounded daily.

Fun and Games

The state lottery

EXAMPLE

The state you live in has two numbers different 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 1 50 MATH ▼ 2 6 ENTER .

```
                0.
50C6=
        15890700.
```

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

2. Press 35 MATH ▼ 3 5 ENTER .

```
        15890700.
35P5=
        38955840.
```

RESULT

Your chances are better in the first lottery.

Fun and Games

Putting on the bite

EXAMPLE

Mary visits the dentist. She spends exactly 25 minutes in the surgery having her teeth checked, and the bill for her visit comes to $93.50. What is the dentist's equivalent wage per hour?

Press MODE 1 [CA] 93.50 ÷ 0.25 MATH ▼ ▼ 1 ENTER .

```
93.50/0.25→DEG
=
          224.40
```

RESULT

$224.40 an hour.

Memory Calculation

The take

When you want to use the calculator for tasks like adding up total sales, do not be discouraged by the fact that the keypad has no [M+] (add to memory) and [M−] (subtract from memory). You can perform this type of operation using one-variable statistics.

EXAMPLE

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

Item	Price	Q'ty
Television	$599.95	10
Telephone	$159.95	27
Clock	$ 39.95	52
Calculator	$ 7.95	108

1. Press [MODE] [1] [SET UP] [4] [1] [QUIT].
   - Selects STATx mode.

2. Press 599.95 [×] 10 [DATA] 159.95 [×] 27 [DATA] 39.95 [×] 52 [DATA] 7.95 [×] 108 [DATA].
   - All the data is entered.
   - You are using [DATA] as you would [M+] and [CD] as you would [M−].

```
n=              3.
7.95*108DATA
n=              4.
```

3. Press [STAT] [4] [ENTER].
   - The calculator displays Σx, which is the total sales figure.

```
n=              4.
Σx=
        13254.15
```

RESULT

Total sales were $13254.15

APPENDIX

Replacing the Battery

The calculator uses one lithium battery as its DC power supply.

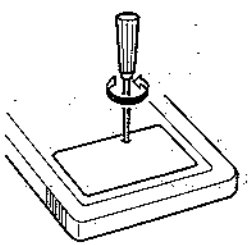
Notes on erasure of memory contents
When the battery is replaced, the memory contents are erased. Erasure can also occur if the calculator is defective or when it is being repaired. Make a note of all important memory contents in case accidental erasure occurs.

When to replace the battery

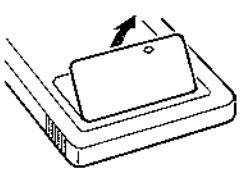
If the characters and indicators in the display appear dim, try adjusting the display contrast (☞ p. APP-4) to make the display darker. If this does not help, it is a sign that the battery voltage is low, meaning that the battery is nearing the end of its life. Replace the battery as quickly as possible. Note that use of the calculator with an exhausted battery may result in loss of the memory contents.

Installing the battery

1. Turn the calculator off by pressing [OFF].
2. Remove the screw from the rear of the calculator using a Phillips screwdriver.

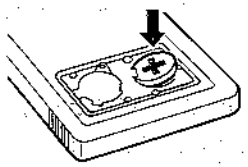


3. Remove the battery cover.

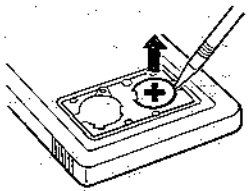


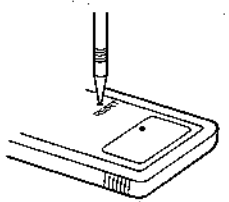
Replacing the Battery

4. Remove the old battery from the battery compartment and replace it with a new one (CR-2025 lithium battery).
   - Make sure the positive (+) terminal is facing upwards after installing the battery.



5. Replace the battery cover and screw.





6. Press the reset switch using the tip of a ball-point pen.
   - If you do not see the message on the right, repeat steps 1-5.

```
ALL DATA CL?
 YES→[CL]
  NO→[QUIT]
```

7. Press [CL] and then press any key.
   - The initial display of REAL mode appears.

```
REAL MODE.
                0.
```

8. Adjust the display contrast.

Safety precautions
- Keep the battery out of reach of children.
- Dispose of the old battery safely. The battery may explode if it is placed in a fire.
- The original battery was installed upon shipment from the factory, so its life may be somewhat shorter than indicated in the specifications.
- Remove the battery as soon as it is exhausted or if the calculator is to be stored for a long time. Otherwise the battery may leak and damage the calculator.

The OPTION Menu

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

The OPTION display

Press [OPTION] to call the OPTION menu.

- Select the appropriate option either by pressing the number to its left on the display or by scrolling the screen using [▼] until the required sub-menu appears.
- Press [QUIT] to return to the mode in which you were working previously.

```
   <OPTION>
1:CTRST 2:M.CHK
3:DELETE
```

Contrast

Press [1] in the OPTION menu to call the LCD CONTRAST display.

- Press [+] to darken the display and [−] to lighten it.

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

Note: It is possible to lighten the display so that the calculator appears to be off. If the display remains blank when you press [ON], press [OPTION] [1] and then press [+] repeatedly to darken the display.

Memory check

Press [2] in the OPTION menu to call the MEMORY CHECK display.

- The amount of free memory in bytes is shown in the first line. There are approximately 1.2 kilobytes of free memory available when the calculator is used for the first time.

```
 624BYTES FREE
EQTN:SOLV:PROG
  03    05    01
```


The OPTION Menu

- The numbers under EQTN, SOLV and PROG are the numbers of equations and/or programs stored in REAL mode, SOLVER mode and PROGRAM mode, respectively.

For a detailed description of how memory is used, see "Memory usage" (☞ p. APP-17).

Deleting all files

Press [3] in the OPTION menu to call the DELETE DATA menu.

- Press [1], [2] or [3] to delete all files and data that has been stored in REAL, SOLVER or PROGRAM mode, respectively.

After selecting the mode for which all files are to be deleted, press [ENTER] to delete the files or [QUIT] to cancel the operation.

Important note: Once a file has been deleted there is no way to recover it.

To delete individual files, enter the mode that contains the files you want to delete and use the mode specific delete function from the FILE menu. (☞ p. 82, 104)

```
  DELETE DATA
1:EQTN 2:SOLV
3:PROG
```

```
ALL EQTN FILES
  DEL →[ENTER]
  QUIT→[QUIT]
```

After selecting EQTN to delete all REAL mode files

```
ALL SOLV FILES
  DEL →[ENTER]
  QUIT→[QUIT]
```

After selecting SOLV

```
ALL PROGRAMS
  DEL →[ENTER]
  QUIT→[QUIT]
```

After selecting PROG

Error Messages

The following is a table of common error messages and suggestions for correcting the error.

Error no.	Error message	Problem/solution
01	SYNTAX	Verify that you are using the proper syntax for the function you are trying to use.
02	CALCULATION	Check that you have not attempted to divide by zero or made some other calculation error.
03	NESTING	Make sure your equation has less than 8 numbers and 16 functions.
14	NO VARIABLE	Make sure that all variables in the faulty line are defined (solver mode only).
20	LBL DUPLICATE	Make sure that your program does not use the same label name to specify more than one location.
21	LBL UNDEFINED	Make sure your program does not have a GOTO or GOSUB command pointing to a label that does not exist. However, you can include labels that are not pointed to by any GOTO or GOSUB command without affecting program operation.
22	LBL OVER	Make sure your program does not have more than 20 labels.
23	GOSUB STACK	Make sure your program does not have more than 10 levels of nested subroutines.
24	LINE TOO LONG	Make sure the faulty line has less than 160 characters.

Error Messages

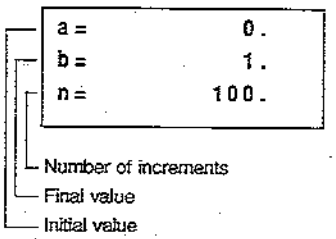
Error no.	Error message	Problem/solution
30	CAN'T RETURN	A RETURN command appears in a program, but it has no corresponding GOSUB command.
40	INVALID n	Check that the number of intervals (n) is a positive integral number less than 4999999999.
41	RANGE a >= b	Check that the lower limit of the integration range or the range of expected values for the solver function is smaller than the upper limit.
90	MEMORY OVER	There is not enough free memory left for what you are trying to do. Delete unneeded files and try again.
(No number)	BREAK	You have pressed [QUIT] (or [ON]) to stop a program or solver calculation. Press [◀] or [▶] to go to the last executed command or press [QUIT] (or [CL]) to return to the initial display.

Using the Integration Function Effectively

The calculator uses Simpson's rule to perform integration. For this reason it may take some time to find a solution. Also, the nature of Simpson's rule means that solutions may include significant errors.

Number of increments

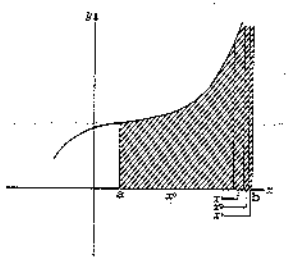
If you press ∫ dx = ?] after an integration expression has been entered, the calculator prompts you for the integration limits (a and b) and the number of increments (n) (☞ p. 72). The accuracy of a solution depends on the number of increments you specify. If you press [SOLVE] without specifying the number of increments, the calculator automatically assumes a default value of n = 100.

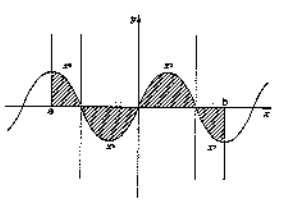


Improving integration accuracy

A large integration error may occur in cases where a small change in the integration range significantly affects the integral value or where an integral range covers two or more quadrants. (The same is true for periodic functions.)

In such cases, divide the integral section into segments and use a large number of increments for segments with very steep slopes or use separate integral expressions for different quadrants.



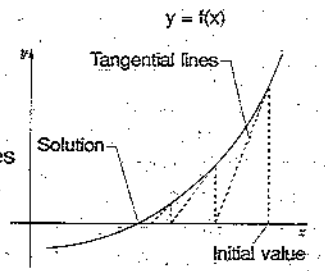


Using the Solver Function Effectively

The calculator uses Newton's method to solve equations. 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 method using 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 the [SOLVE] key is pressed for the first time, the calculator takes the value that is stored in memory for the unknown variable, or zero if no value is stored, to be its initial expected value 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 up a "dead end" — the calculator will abort calculation and display a message to indicate this.

```
TRY AGAIN!
ADJUST RANGE/
VARIABLE VALUE
```

Using the Solver Function Effectively

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. This range is from -1×10^{10} to $+1 \times 10^{10}$ by default, but can be narrowed down or extended (to a maximum of -1×10^{99} to $+1 \times 10^{99}$) by pressing [RANGE] and setting the lower and upper limits a and b. To choose which initial expected values to try, the calculator divides the calculation 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 12-digit internal operations. It may therefore present one of the "approximate" values as a solution if the value of the left-hand side is sufficiently close to agreeing with that of the right-hand side — even though it is not the true solution. The calculator will also stop trying to solve "approximate" solution either when it has performed 40 iterations using each initial expected value or when it has obtained an "approximate" solution which is the same (to 10-digit accuracy) twice in succession.

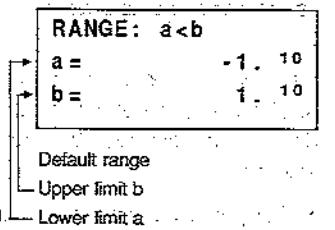
Using the Solver Function Effectively

- For example, if you solve the equation $x^2 - 4x + 4 = 0$ using an initial expected value (i.e. the value previously stored for the unknown variable) of 4, the calculator displays 2.000009692 as the solution even though the true answer is 2. This solution provides a sufficiently close approximation to the solution according to the calculator's judgment criteria.

Changing the range of expected values

After entering your equation by pressing [ENTER], press [RANGE] 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 changed.



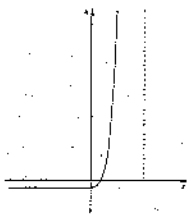
After entering the lower and upper limits (a and b) of the range of expected values, press [SOLVE]. The calculator will start solving the equation using the new range.

- 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 [SOLVE] 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.

Using the Solver Function Effectively

Equations that are difficult to solve

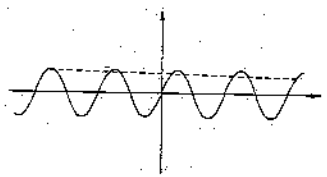
Newton's method has problems in solving certain types of equations, either because the tangential lines it uses to approximate the solutions iterate only slowly toward the correct answer, or because they do not iterate there all at all. Examples of such equations include equations of which steep slopes 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. $y = 8/x + 1$).



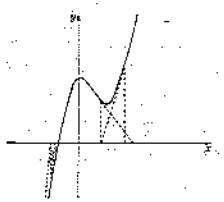
Solving $y = 10^x - 5$ for $y = 0$. Because of the steep slope, it takes a long time to iterate to the correct solution. Set limits a and b as close as possible either side of your expected solution.

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, so the calculator may iterate to a totally different cycle of the function and will not obtain an accurate solution if the initial expected value falls too close to a peak or trough. 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 variables is no longer found as a denominator.



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



$y = x^3 - 3x^2 + x + 5 = 0$.
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

This section describes calculation accuracy and memory usage.

Accuracy

For four basic arithmetic operations, numbers entered as the first and second operands and calculation results must be within the ranges:

from $+1 \times 10^{-99}$ to $+9.999999999 \times 10^{99}$
or from -1×10^{-99} to $-9.999999999 \times 10^{99}$
or 0.

The calculator regards all numeric entries or calculation results whose absolute values are less than 1×10^{-99} as 0 (zero).
Additional restrictions on the numerical ranges of entries and results for other functions of the calculator are shown in the following table.

Function(s)	Numerical range
sin x, cos x, tan x	DEG: $\lvert x \rvert < 1 \times 10^{10}$ RAD: $\lvert x \rvert < \frac{\pi}{180} \times 10^{10}$ GRAD: $\lvert x \rvert < \frac{10}{9} \times 10^{10}$ For tan x, however, an error occurs in the following cases: DEG: $\lvert x \rvert = 90 (2n - 1)$ RAD: $\lvert x \rvert = \frac{\pi}{2} (2n - 1)$ GRAD: $\lvert x \rvert = 100 (2n - 1)$ (where n = integer)
$\sin^{-1} x$, $\cos^{-1} x$	$-1 \leqq x \leqq 1$
$\tan^{-1} x$	$\lvert x \rvert < 1 \times 10^{100}$
ln x, log x	$1 \times 10^{-99} \leqq x < 1 \times 10^{100}$
e^x	$-1 \times 10^{100} < x < 230.2585093$
10^x	$-1 \times 10^{100} < x < 100$

Technical Data

Function(s)	Numerical range
y^x	$y > 0$: $-1 \times 10^{100} < x \log y < 100$ $y = 0$: $0 < x < 1 \times 10^{100}$ $y < 0$, where x is an integer or $\frac{1}{x}$ is an odd number ($x \neq 0$): $-1 \times 10^{100} < x \log \lvert y \rvert < 100$
$\sqrt[x]{y}$	$y > 0$: $-1 \times 10^{100} < \frac{1}{x} \log y < 100$ ($x \neq 0$) $y = 0$: $0 < y < 1 \times 10^{100}$ $y < 0$, where x is an odd number or $\frac{1}{x}$ is an integer ($x \neq 0$): $-1 \times 10^{100} < \frac{1}{x} \log \lvert y \rvert < 100$
sinh x, cosh x, tanh x	$-230.2585093 < x < 230.2585093$
$\sinh^{-1} x$	$\lvert x \rvert < 1 \times 10^{50}$
$\cosh^{-1} x$	$1 \leqq x < 1 \times 10^{50}$
$\tanh^{-1} x$	$\lvert x \rvert < 1$
$\sqrt{x}$	$0 \leqq x < 1 \times 10^{100}$
x^2	$\lvert x \rvert < 1 \times 10^{50}$
x^{-1}	$\lvert x \rvert < 1 \times 10^{100}$ ($x \neq 0$)
n!	$0 \leqq n \leqq 69$ (where n = integer)
nCr, nPr	$0 \leqq r \leqq 69$, $r \leqq n \leqq 9999999999$ where ${}_nC_r < 1 \times 10^{100}$, ${}_nP_r < 1 \times 10^{100}$ and r, n = integer
→DEC, →BIN, →OCT, →HEX AND, OR, NOT, XOR, XNOR	DEC: $\lvert x \rvert \leqq 9999999999$ BIN: 1000000000000000 ≦ x ≦ 1111111111111111 0 ≦ x ≦ 0111111111111111 OCT: 4000000000 ≦ x ≦ 7777777777 0 ≦ x ≦ 3777777777 HEX: FDABF41C01 ≦ x ≦ FFFFFFFFFF 0 ≦ x ≦ 2540BE3FF For conversions, these ranges apply to the converted results.

Technical Data

Function(s)	Numerical range
NEG	BIN: 1000000000000001 ≦ x ≦ 1111111111111111 0 ≦ x ≦ 0111111111111111 OCT: 4000000001 ≦ x ≦ 7777777777 0 ≦ x ≦ 3777777777 HEX: FDABF41C01 ≦ x ≦ FFFFFFFFFF 0 ≦ x ≦ 2540BE3FF
→rθ	$\lvert x \rvert < 1 \times 10^{100}$, $\lvert y \rvert < 1 \times 10^{100}$ $\sqrt{x^2+y^2} < 1 \times 10^{100}$ $\left\lvert \frac{y}{x} \right\rvert < 1 \times 10^{100}$
→xy	$\lvert r \rvert < 1 \times 10^{100}$ The same ranges apply to the angle as for trigonometric functions.
→DMS, →DEG	$\lvert x \rvert < 1 \times 10^{100}$
Statistics	$\lvert x \rvert < 1 \times 10^{50}$, $\lvert y \rvert < 1 \times 10^{50}$ $\lvert \Sigma x \rvert < 1 \times 10^{100}$, $\lvert \Sigma y \rvert < 1 \times 10^{100}$ $\Sigma x^2 < 1 \times 10^{100}$, $\Sigma y^2 < 1 \times 10^{100}$ $\lvert \Sigma xy \rvert < 1 \times 10^{100}$ $\lvert n \rvert < 1 \times 10^{100}$
$\bar{x}$	$n \neq 0$
sx	$n > 1$ $\lvert \Sigma x \rvert < 1 \times 10^{50}$ $0 \leqq \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1} < 1 \times 10^{100}$
σx	$n > 0$ $\lvert \Sigma x \rvert < 1 \times 10^{50}$ $0 \leqq \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n} < 1 \times 10^{100}$

Technical Data

Function(s)	Numerical range
$\bar{y}$, sy, σy	The same ranges apply as for $\bar{x}$, sx, σx, respectively.
r	$n > 0$ $\lvert \Sigma x \rvert < 1 \times 10^{50}$ $\lvert \Sigma y \rvert < 1 \times 10^{50}$ $0 < (\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n}) < 1 \times 10^{100}$ $\lvert \Sigma xy - \frac{\Sigma x \Sigma y}{n} \rvert < 1 \times 10^{100}$ $\frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\sqrt{(\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n})}} < 1 \times 10^{100}$
b	$n > 0$ $\lvert \Sigma x \rvert < 1 \times 10^{50}$ $\lvert (\Sigma x)(\Sigma y) \rvert < 1 \times 10^{100}$ $0 < \lvert \Sigma x^2 - \frac{(\Sigma x)^2}{n} \rvert < 1 \times 10^{100}$ $\lvert \Sigma xy - \frac{\Sigma x \Sigma y}{n} \rvert < 1 \times 10^{100}$ $\lvert \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}} \rvert < 1 \times 10^{100}$
a	The same ranges apply as for b with the addition of the following: $\lvert b\bar{x} \rvert < 1 \times 10^{100}$ $\lvert \bar{y} - b\bar{x} \rvert < 1 \times 10^{100}$
y'	$\lvert bx \rvert < 1 \times 10^{100}$ $\lvert a + bx \rvert < 1 \times 10^{100}$
x'	$\lvert y - a \rvert < 1 \times 10^{100}$ $\lvert \frac{y - a}{b} \rvert < 1 \times 10^{100}$

Technical Data

As a rule, the error in function calculations is less than ±1 with respect to the lowest digit of a displayed numerical value (the lowest digit of the mantissa in scientific notation) within the above calculation ranges. However, near significant points and inflection points, errors can become much larger than this.

Memory usage

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

Variables

In all modes, each global variable uses 1 byte (for the character) and each local variable uses 8 bytes.

Programs

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

On top of this, 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-line program shown below uses 59 bytes.

	Line	Characters	Commands	Local variables	Total
Program title	—	—	—	—	32 bytes
IF A=0 GOTO ABC	3 bytes	5 bytes	3 bytes	—	11 bytes
$A_1 = A+1$	3 bytes	4 bytes	1 byte	8 bytes	16 bytes
Total consumption	6 bytes	9 bytes	4 bytes	8 bytes	59 bytes

Expression solver, integration and solver functions

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

Function Count

The following tables list all the functions of the EL-5120 calculator.

Basic functions		No.
Memory	STO/RCL, A–Z, θ, ANS, VAR (× 9)	81
Arithmetic	÷, −, ×, ÷, (−), Exp	
Pending operations	16 calculation instructions and 8 numbers	
Play-back function	[←], [→]	
Editing	BS, DEL, INS mode, [←], [→], [↑], [↓], CL, CA	
SET UP functions		**No.**
Angle unit	DEG, RAD, GRAD	25
Display format	FLOAT, FIX, SCI, ENG	
Tab	0–9	
Answer	Decimal ↔ mixed ↔ improper	
STAT data format	STATx, STATxy	
REAL mode		**No.**
Trigonometric	sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$ (for each angular unit)	79
Hyperbolic	sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$	
Logarithmic/exponential	ln, log, e^x, 10^x	
Power	y^x, $\sqrt[x]{}$, x^2, $\sqrt{}$, x^{-1}	
Factorial	n!, nPr, nCr	
DEG↔DMS	→DMS, →DEG	
Coordinate conversion	→xy, →rθ	
Fractions	a/b	
Others	ABS, IPART, FPART, INT, MOD, π, RANDOM, →RAND, Exp	
STAT data entry	x[DATA], x,w[DATA], x,y[DATA], x,y,w[DATA], [CD]	

Function Count

REAL mode (continued)		No.
One-variable statistics	Σx, Σx^2, $\bar{x}$, sx, σx, n	
Two-variable statistics	Σy, Σy^2, $\bar{y}$, sy, σy, Σxy	
Linear regression	r, a, b, x′, y′	
Equations	Expression solver, numeric integration, equation file (SAVE, LOAD, DEL)	
NBASE mode		**No.**
Conversion	→BIN, →OCT, →HEX, →DEC	18
Logical operations	AND, OR, NOT, NEG, XOR, XNOR	
SOLVER mode		**No.**
Solving range	Solving range (RANGE), solver equation file, solver file menu (RUN, EDIT, NEW, DEL)	6
PROGRAM mode		**No.**
Program type	REAL, NBASE	28
Commands		
Display, input	PRINT, PRINT*, INPUT, WAIT, REM, END	
Branches, subroutines	LABEL, GOTO, IF, <, <=, >=, >, =, ≠, GOSUB, RETURN	
Clear display	CLRT	
Statistics	STATx, STATxy, DATA	
Program file	Within user area	
OPTIONS		**No.**
	Display contrast, Memory check	5
Data deletion	Delete all EQTN, SOLV, PROG	
TOTAL		242

Specifications

Model:	EL-5120
Display type:	[14 characters and 2 exponents] × 3 rows
Dot matrix characters:	5 × 5 dots/character
Calculation system:	D.A.L. (Direct Algebraic Logic) result display (with priority judging function)
Number of display digits:	10-digit mantissa + 2-digit exponent
Number of internal calculation digits:	12-digit mantissa
Display formats:	Floating point, fixed point, scientific notation, engineering notation and fractions
Calculation functions:	Calculations (four basic arithmetic operations, calculations with parentheses, memory calculations, function calculations and coordinate conversion), binary/octal/decimal/hexadecimal conversion, logical operations, statistical calculations, etc.
Statistical functions:	One-variable statistics, two-variable statistics, weighted data input
Expression solver function:	Substitution, storage of expression solver equations, etc.
Numerical integration function:	Simpson's law analysis, storage of integration equations, etc.
Solver function:	Newton's method analysis, storage of solver equations, etc.
Options:	Display contrast control, free memory check and data deletion
Memory capacity:	1211 bytes (user area)
Power supply:	Lithium battery (CR-2025) × 1
Auto power off:	After approximately 10 minutes

Specifications

Power consumption:	0.003 W
Operating temperature:	0°C to 40°C (32°F to 104°F)
Operating time:	Approximately 1100 hours* (at 20°C (68°F), assuming each hour comprises 5 minutes of continuous operation and 55 minutes of display time).
Dimensions:	76 (W) × 145 (D) × 9.8 (H) mm (3 (W) × $5\frac{23}{32}$ (D) × $3\frac{3}{8}$ (H) inch)
Weight:	77g (0.169lbs.) (including battery, but not including hard case)
Accessories:	1 lithium battery (installed), operation manual and quick reference card

* This value may vary according to the type of battery and the way the calculator is used.