CASIO

SCIENTIFIC CALCULATOR

fx-61F

CASIO

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1/MEET THE SCIENTIFIC CALCULATOR

The scientific calculator differs from the standard type in that it has many more keys and that each key has a number of different functions. In this section you will learn the general flow of basic operations for your scientific calculator. We recommend that you spend a few minutes reading through this section before continuing on to actual operation.

1. Reading the Key Function Indicators

As mentioned above, each key of the scientific calculator is capable of a variety of functions. For example, you would use a key such as the one illustrated below for: sin, $\sin^{-1}$, and HEX (what each of these markings means will be covered later in this manual.

sin⁻¹
[sin]
HEX

With this key, simply pressing it will perform the sin function, pressing it following the [SHIFT] key performs the $\sin^{-1}$ function, while the HEX specification is performed when the key is pressed in the BASE-N mode (page 4). Besides these three, some keys are marked with other functions that can only be performed in the SD (standard deviation) mode (see page 4 for modes).

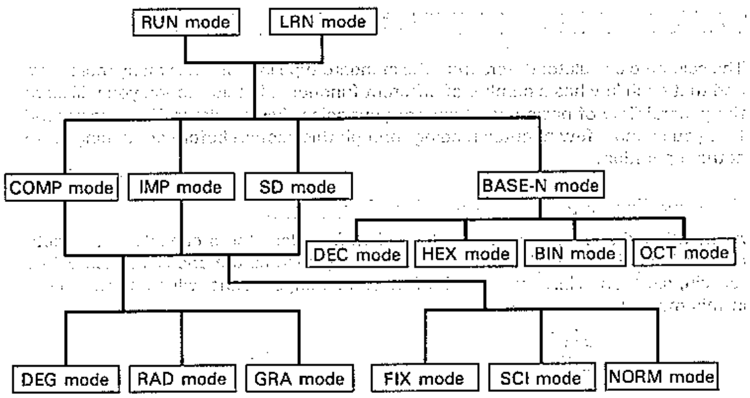
Of course all of this may sound a little hard to remember. To help you keep them straight, the function markings that appear above and below the keys have been color coded and specially marked. Note the following:

Marking	Meaning
Orange	Press after [SHIFT].
Green	Perform in BASE-N mode.
[ ]	Perform in SD mode.

2. Understanding Modes

Before you start your calculations on a scientific calculator, you must first tell it how to handle the information you are about to input. The condition that the calculator goes into at this time is called a ***mode***.

Once you put the calculator into a mode, you may be required to make one or more further choices. The following illustration shows all of the modes possible, and their relationship with each other.



LRN:	Learn	RAD:	Radians
COMP:	Compute	GRAD:	Grads
IMP:	Impedance	FIX:	Number of decimal places.
SD:	Standard deviation	SCI:	Number of significant digits
DEG:	Degrees	NORM:	Normal

You can change the mode of the calculator by pressing the MODE key followed by a number. For your convenience, we have included a table of modes and the method you should use to specify them right under the calculator's display.

■ Operation Modes

MODE · — RUN mode

You should use this mode for manual calculations (those in which you manually press each key as needed) and to run programs. In this mode, you can execute the built-in formulas and scientific functions.

MODE EXP — LRN mode

Use this mode to store and erase programs. The symbol LRN is shown on the display while the calculator is in this mode.

■ Calculation Modes

MODE 0 — COMP mode

Use this mode for general calculations, including those that employ scientific functions. You should remember when using the COMP mode that the values you input are handled according to the current angle mode specification, even though the specification is not indicated on the display.

MODE 1 — BASE-N mode

Use the BASE-N mode for binary/octal/decimal/hexadecimal conversions and calculations, as well as for logical (Boolean) operations. The symbol BASE-N is shown on the display while the calculator is in this mode.

MODE 2 — IMP mode

Use the IMP mode for impedance calculations. The symbol IMP is shown on the display while the calculator is in this mode.

MODE 3 — SD mode

Use the SD mode for standard deviation calculations. The symbol SD is shown on the display while the calculator is in this mode.

* Only one calculation mode can be in effect at any time — they cannot be used in combination.

■ Angle Modes

MODE 4 — DEG mode

Use this mode to calculate in degrees. The symbol D is shown on the display while the calculator is in this mode.

MODE 5 — RAD mode

Use this mode to calculate in radians. The symbol R is shown on the display while the calculator is in this mode.

MODE 6 — GRA mode

Use this mode to calculate in grads (100 grads = $\pi/2$rad = 90°). The symbol G is shown on the display while the calculator is in this mode.

* The angle modes are used in combination with calculation modes (except for BASE-N).

■ Display Modes

MODE 7 — FIX mode

Use the FIX mode to specify the number of decimal places for the fractional part of a value. The symbol FIX is shown on the display while the calculator is in this mode.

[MODE] [8] — SCI mode

Use the SCI mode to specify the number of significant digits for a value. The symbol SCI is shown on the display while the calculator is in this mode.

[MODE] [9] — NORM mode

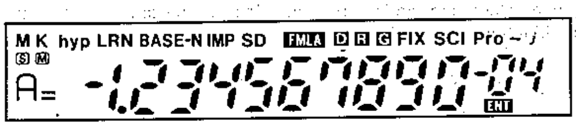
Use the NORM mode to cancel specifications made in the FIX and SCI modes. No symbol is shown on the display while the calculator is in this mode.

* The display modes are used in combination with calculation modes (except for BASE-N).
  All these modes that are previously specified are retained even when the calculator is switched off by the Auto Power Off function.

3. Reading the Display

■ Symbols and Indicators

When you look at the display of the calculator, you can see various symbols and indicators. These tell you the status and mode of the calculator.



M : Displayed when there is something stored in the independent memory.
K : Remains on the display during constant calculations.
[S] : Appears on the display when you press the [SHIFT] key.
[M] : Appears on the display when you press the [MODE] key.
hyp : Appears on the display when you press the [hyp] key.
LRN : Displayed while the calculator is in the LRN mode.
BASE-N : Displayed while the calculator is in the BASE-N mode.
IMP : Displayed while the calculator is in the IMP mode.
SD : Displayed while the calculator is in the SD mode.
FMLA : Displayed during execution of a built-in formula.
D : Displayed while degrees are specified as the angle unit.
R : Displayed while radians are specified as the angle unit.
G : Displayed while grads are specified as the angle unit.
FIX : Displayed while the number of decimal places is specified.
SCI : Displayed while the number of significant digits is specified.
Pro : Displayed while a program is being executed or when the computer is in the LRN mode.
⇀ : Appears to indicate that the result of an impedance calculations contains both a real value and an imaginary value.

i : Displayed while the imaginary value of an impedance calculation is displayed.
ENT : Displayed while the calculator is standing by for data input during program execution.

■ Exponential Displays

The display can show values only up to 10 digits long. When calculation results are longer, the calculator automatically switches over to exponential notation. Values greater than 9,999,999,999 or less than 0.01(10^{-2}) are displayed exponentially.

• Notes on Exponential Notation

A value that is expressed exponentially takes up much less space. To convert a positive value from exponential notation, look at the exponent for the number 10 in the exponential notation. Then move the decimal place of the value to the right, the same number of places, adding zeros as needed. For example:

1.2^{11}

Mantissa Exponent

➡ 1.2×10^{11} ➡ 120,000,000,000

1.2 Delete
00000000000 ➡ 120000000000
11 digits
1.2×10^{11}

Negative values are handled the same way, except that you move the decimal place to the left instead of the right. For example:

1.2^{-03}

Mantissa Exponent

➡ 1.2×10^{-3} ➡ 0.0012

1.2 Delete

0.000 ➔ 0.0012

3 digits

1.2×10^{-3}

You can find further information on the use of exponential notation on page 11.

• **Hexadecimal/Sexagesimal Display Formats**

The hexadecimal display and angle in the sexagesimal scale are displayed as follows.

A B C D E F 1 2

AbCdEF 12. [ABCDEF12_{16} (=-141256727_{10})]

Degrees Minutes Seconds

12° 34° 56.78 (12°34'56.78")

2/BEFORE USING YOUR CALCULATOR

Note the following safety precautions before using your calculator.

- Avoid damage to precision components by guarding your calculator against exposure to temperature extremes, high humidity, dust, sudden temperature changes, and strong impact. Low temperatures can slow down the display speed or even cause the display to fail completely. This is generally temporary, and normal operations should return at warmer temperatures.
- When the calculator is performing internal calculations, the display will clear and key operation will be impossible. Before entering data, check the display to confirm that the calculator is ready for further input.
- Never attempt your own maintenance or try to take the calculator apart.
- Never incinerate old batteries.
- Never use thinner, benzine or other volatile agents for cleaning. Clean the exterior of the calculator with a soft cloth that has been dampened with a solution of water and a mild neutral detergent.
- The manufacturer assumes no responsibility for claims from third parties for loss or damages arising through the use of this calculator.
- The manufacturer assumes no responsibility for any loss or damages arising from loss of data and/or programs incurred while using this calculator.

3/ABOUT POWER SUPPLIES

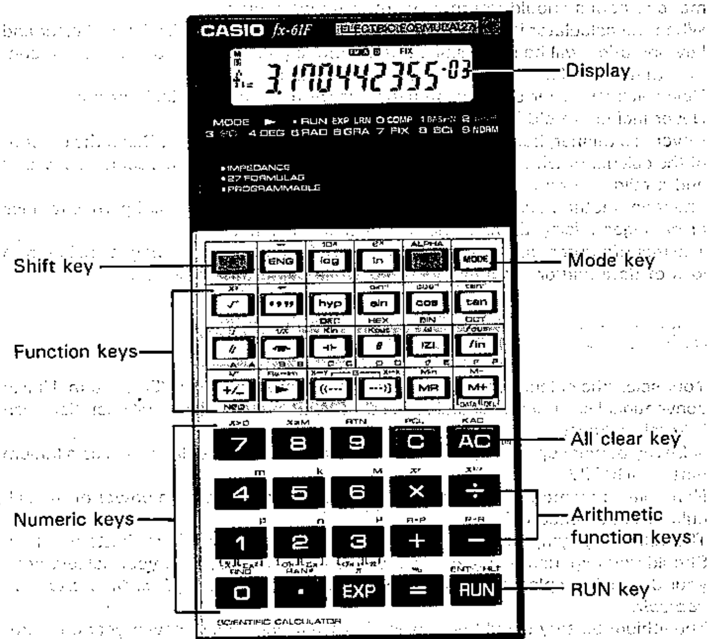
- Your scientific calculator is powered by the innovative C-POWER system. Unlike conventional solar power sources, the C-POWER system allows full operation even in total darkness.
- A 2-way power supply employs both an amorphous solar cell, as well as a lithium battery (GR927).
- Non-volatile memories retain memory contents even when the power of the calculator is switched off.
- The following symptoms indicate that the power of the lithium battery is low. Should you experience one or more of these symptoms, take your calculator to your dealer for replacement of the battery. ***Do not try to replace the battery by yourself.***
  The lithium battery should be replaced at least once every seven years, regardless of how much you have used your calculator.

* Clearing of the independent or constant memory values to "0.".
* Clearing of programs.
* Dim display during calculations where lighting is weak.
* Nothing shown on the display, even if you press the AC key.

Auto Power OFF function

This unit automatically switches OFF if not operated for approximately 6 minutes. Power can be restored by pressing the AC/ON key. Memory contents and mode setting are retained even when power is switched off.

4/GENERAL GUIDE



■ Internal Registers

The following illustration shows the different registers used by the calculator, as well as the data that is stored in each register.

Register	Data stored
X register	• Arithmetic and scientific function calculations
Y (L1) register	• Arithmetic and scientific function calculations
Y (L2) register	• Calculations that require prioritizing of arithmetic functions, terms contained in parentheses, etc. (see page 17).
Y (L3) register	
Y (L4) register	
Y (L5) register	
Y (L6) register	
M register	• Independent memory ([Min], [M+], [M-], [MR])
K1 (Σx^2) register	• Constant memories • Data storage during impedance calculations • Data accumulation during statistical calculations • Storage of built-in formula data
K2 (Σx) register	
K3 (n) register	
K4 register	
K5 register	
K6 register	

[SHIFT] Shift key

Changes the function of a key to the function marked in orange above the key. When you press [SHIFT] the [S] symbol appears on the display. Pressing [SHIFT] again while [S] is displayed cancels the shift and causes [S] to disappear from the display.

[MODE] Mode key

Press this key followed by [EXP], [•], or [0] through [9] to set the mode or angle unit of the calculator. See page 2 for details on the modes available.

[1] – [9], [0], [•] Numeric keys

Use these keys to enter values. A value can be up to ten digits long. Following the [SHIFT] key, the numeric keys perform the following functions.

• [SHIFT][RND 0] – Internal rounding

Internal values (stored in the Y register) can be longer than those appears on the display, since the display has a 10-digit capacity. The above operation makes the internal value and the displayed value identical.

Values that fall within the range of $1 > x \geq .01$ are rounded off to 10 digits.

• [SHIFT][RAN# •] – Random number generation

This operation generates pseudo-random numbers within the range of 0 to .999.

In the SD mode ([MODE] [3]), the numeric keys perform the following functions.

- [SHIFT][1] — $\bar{x}$ (mean of x)
- [SHIFT][2] — σ_n (population standard deviation)
- [SHIFT][3] — σ_{n-1} (sample standard deviation)
- [Kout][1] — Σx^2 (sum of squares)
- [Kout][2] — Σx (sum)
- [Kout][3] — n (number of data)

For details on these functions, see the section of this manual titled *Performing Standard Deviation Calculations.*

[EXP] Exponent/Pi key

Press this key after entering the mantissa part of a value when you are using exponential notation (i.e. $2.56 \times 10^{34} \rightarrow 2.56$ [EXP] 34). The maximum value of the exponent is ±99.

This key is also used to enter the value for pi. You can press this key (without [SHIFT] preceding it) if you have not yet entered any numeric value. Following entry of a numeric value, you can enter pi by first pressing [SHIFT], following by [EXP].

[+][−][×][÷][=] Arithmetic operation keys

Arithmetic operations are entered by pressing the keys in the same sequence as the operation is written, from left to right. Then pressing the [=] key produces the result of the operation. Pressing any of the arithmetic key twice after entering a value makes that value a constant (see page 22 for details).

The arithmetic operation keys perform the following functions when they are pressed following the [SHIFT] key:

- [SHIFT][+] — Coordinate conversion (R→P)

Converts from rectangular coordinates to polar coordinates.

- [SHIFT][−] — Coordinate conversion (P→R)

Converts from polar coordinates to rectangular coordinates.

- [SHIFT][×] — Power

Press to calculate x (entered value) to the yth (entered value) power.

- [SHIFT][÷] — Root

Press to calculate the yth (entered value) root of x (entered value).

- [SHIFT][=] — Percent

Press for calculations involving regular percentages, add-ons, discounts, ratios and increase/decrease values.

Percent calculation cannot be performed in the IMP mode and BASE-N mode.

[C] Clear/Program clear key

Use this key to clear wrong entries, to clear irregular result of function execution, or to clear intermediate results (produced by expressions contained in parentheses). This key clears the displayed value only (from the X register), while retaining previous intermediate results. This key can also be used to clear the "−E−" display (produced when a register overflow occurs for a mixed calculation or parenthetical calculation, again while retaining previous results.

You can also use this key following [SHIFT] in the LRN mode ([MODE] [EXP]) to clear a program.

[AC]ON All Clear/Constant Memory Clear/Power ON key

Use this key to clear the entire machine except the independent memory (M register), constant memories (K registers) and program contents.

Pressing this key following [SHIFT] clears the constant memories.

You can also use this key to restore power that has been cut off by the Auto Power OFF functions (page 8).

[ENG] Engineering key

Each press of this key shifts the decimal of the displayed value three decimal places to the right.

This in effect results in conversion of the value from one metric unit to another such as 10^{-3} milliseconds = 10^{-6} microseconds = 10^{-12} picoseconds.

Example: 12.3456

	12.3456	
1st [ENG]	12.3456 ^{00}	
2nd [ENG]	12345.6 $^{-03}$	
3rd [ENG]	12345600. $^{-06}$	
4th [ENG]	12345600. $^{-06}$	(No change)

When this key is pressed following [SHIFT] the decimal point is shifted to the left, for such metric conversions as 10^3 kilohertz = 10^6 megahertz = 10^9 gigahertz.

Example: 12.345

	12.345	
1st [SHIFT][ENG]	0.012345 ^{03}	
2nd [SHIFT][ENG]	0.000012345 ^{06}	
3rd [SHIFT][ENG]	0.000000012 ^{09}	
4th [SHIFT][ENG]	0.000000012 ^{09}	(No change)

[log] Logarithm/Antilogarithm key

Press this key to determine the common logarithm (base 10) of a value. Following [SHIFT], press to calculate the antilogarithm (xth power of 10).

[ln] Natural Logarithm/Exponential key

Use this key to calculate the natural logarithm (base e = 2.7182818......) of a value. Following [SHIFT], press to calculate the xth power of e.

[FMLA] Built-in Formula Recall/ALPHA key

Press this key following entry of a value from 1 to 27 to recall a built-in formula. In the LRN mode ([MODE] [EXP]), press this key prior to entering a variable name ([A] ~ [F]).

[√] Square root/Square key

Press this key to calculate the square root of the displayed value. To square the displayed value, first press [SHIFT] and then this key.

[°'"] Decimal ↔ Sexagesimal Conversion key

When inputting a sexagesimal value, press this key after each part (hour, minute, second) of the value. To enter 14°25'36", press: 14 [°'"] 25 [°'"] 36 [°'"].
Pressing this key after [SHIFT] converts a displayed decimal value to its sexagesimal equivalent.

[hyp] Hyperbolic key

This key obtains the corresponding hyperbolic functions when it is pressed before the [sin] (sinh), [cos] (cosh), and [tan] (tanh) keys. Following [SHIFT] (as in [SHIFT] [hyp] [sin]), this key obtains the inverse hyperbolic functions for [sin] ($\sinh^{-1}$), [cos] ($\cosh^{-1}$), and [tan] ($\tanh^{-1}$).
In the BASE-N mode ([MODE] [1]), this key is used to enter decimal values, and to convert non-decimal values to decimal.

[sin] Sine/Arc sine key

This key returns the sine of the displayed value.
Following [SHIFT], pressing this key determines the arc sine of the value.
In the BASE-N mode ([MODE] [1]), this key is used to enter hexadecimal values and to convert non-hexadecimal values to hexadecimal.

[cos] Cosine/Arc cosine key

This key returns the cosine of the displayed value.
Following [SHIFT], pressing this key determines the arc cosine of the value.
In the BASE-N mode ([MODE] [1]), this key is used to enter binary values and to convert non-binary values to binary.

[tan] Tangent/Arc Tangent key

This key returns the tangent of the displayed value.
Following [SHIFT], pressing this key determines the arc tangent of the value.
In the BASE-N mode ([MODE] [1]), this key is used to enter octal values and to convert non-octal values to octal.

[//] Parallel Circuit/Imaginary Number key

This key is used for impedance calculations for parallel circuits in the IMP mode ([MODE] [2]), COMP mode ([MODE] [0]), and SD mode ([MODE] [3]).
In the IMP mode, this key is also used following [SHIFT] to enter the displayed value as an imaginary number.
This key is also used to enter the alphabetic character A in the BASE-N mode (hexadecimal value A_{16}) and LRN mode (variable name A).

[⁄x] Coil/Inverse Number key

In the IMP mode ([MODE] [2]), this key calculates impedance, regarding the displayed value as the coil inductance L [H].
In the COMP mode ([MODE] [0]) and SD mode ([MODE] [3]), press this key to return the inverse number of the displayed value. The inverse number can also be determined in the IMP mode by pressing this key after [SHIFT].
This key is also used to enter the alphabetic character B in the BASE-N mode (hexadecimal value B_{16}) and LRN mode (variable name B).

[⊣⊢] Capacitance/Constant Memory Input key

In the IMP mode ([MODE] [2]), this key calculates capacitance, regarding the displayed value as the electrostatic capacitance of a capacitor.
In the COMP mode ([MODE] [0]) and SD mode ([MODE] [3]), press this key to input values into constant memories 1 through 6 (K registers). To enter 12.3 into constant memory 3, for example, press: 12.3 [Kin] [3].
Values can also be input to the constant memories in the BASE-N mode ([MODE] [1]) by pressing [SHIFT] before this key in the above sequence. (Constant memories cannot be used in the IMP mode.)
This key is also used to enter the alphabetic character C in the BASE-N mode (hexadecimal value C_{16}) and LRN mode (variable name C).

[θ] Angle of Deviation/Constant Memory Output key

In the IMP mode ([MODE] [2]), this key calculates angle of deviation for a displayed complex number (composite impedance).
In the COMP mode ([MODE] [0]) and SD mode ([MODE] [3]), press this key to recall values stored in constant memories 1 through 6 (K registers). To recall a value stored in constant memory 5, for example, press: [Kout] [5].
Values can also be output from the constant memories in the BASE-N mode ([MODE] [1]) by pressing [SHIFT] before this key in the above sequence. (Constant memories cannot be used in the IMP mode.)
This key is also used to enter the alphabetic character D in the BASE-N mode (hexadecimal value D_{16}) and LRN mode (variable name D).

[|Z|] Absolute Value/Angular Frequency key

In the IMP mode ([MODE] [2]), press this key to determine the absolute value of the displayed complex number (composite impedance). Following [SHIFT] (in the IMP mode), pressing this key returns the angular frequency of an entered frequency.
This key is also used to enter the alphabetic character E in the BASE-N mode (hexadecimal value E_{16}) and LRN mode (variable name E).

[f in] Frequency Input/Frequency Output key

Use this key in the IMP mode ([MODE] [2]) to enter a displayed value as a frequency. Following [SHIFT] (in the IMP mode), press this key to display a frequency that you have already entered.
This key is also used to enter the alphabetic character F in the BASE-N mode (hexadecimal value F_{16}) and LRN mode (variable name F).

[+/-] Sign Change/Cube Root/Negative key

Press this key to change the sign of the displayed value from positive to negative, or vice versa.
Pressing this key following the [EXP] key changes the sign of the exponent of the displayed value. Following [SHIFT], this key returns the cube root of the displayed value.
In the BASE-N mode ([MODE] [1]), this key returns the negative (two's complement) of the displayed value.

[▶] Backspace/Real Number ↔ Imaginary Number Switch key

When entering values, press this key to backspace one digit to the left. This effectively deletes an entry one digit at a time, and it is useful for correction of input errors.
In the IMP mode ([MODE] [2]), each press of this key switches the displayed value between its real part and imaginary part. Note that the symbol "→←" will be displayed if an impedance calculation produces a result with both a real and imaginary part.

[(...] Open Parenthesis/Register Exchange key

Press this key to enter an open parenthesis. Following [SHIFT], pressing this key exchanges the contents of the X register (displayed value) with those of the Y register (value being used internally by the calculator for an operation).

[...)] Close Parenthesis/Register Exchange key

Press this key to enter a close parenthesis. Following [SHIFT], pressing this key exchanges the contents of the X register (displayed value) with those of a K register (constant memory). An example of the operation for register exchange would be: [SHIFT] [X↔K] [2].

[MR] Memory Recall/Memory In key

Press this key to display the value stored in the independent memory (M register), without changing the register's contents. Following [SHIFT], this key stores the displayed value (X register) in the independent memory (M register). At this time, any value previously stored in the independent memory is lost (i.e. replaced with the new value).

[M+] Memory Plus/Memory Minus/Data Input/Data Delete key

Press this key to add a value to the contents of the independent memory. The value added to the independent memory can either be entered, or it can be the result of an arithmetic operation finalized using this key (in place of [=]). After [SHIFT], this key subtracts the value from the contents of the independent memory.
In the SD mode ([MODE] [3]), pressing this key following a data item enters it. Following [SHIFT], this key deletes the data item specified. For example:
DATA A [DATA] DATA B [DATA] DATA C [DATA] enters data items A, B, and C. Next, DATA B [SHIFT] [DEL] deletes data item B.

[RUN] Run/Entry/Halt key

Press this key to execute (run) a built-in formula.
This key is also used to resume execution of a programmed calculation that has been interrupted.
In the LRN mode ([MODE] [EXP]), this key is used to enter the specification that program execution should pause in order to allow input of data. Following [SHIFT] (in the LRN mode), this key specifies that program execution should halt in order to display an intermediate result.

5/HELPFUL HINTS FOR EASIER CALCULATIONS

The information given in this section should help you to understand the internal workings of the calculator, to help you enter data in the most efficient manner.

■ Order of Operations and Levels

Operations are performed in the following order of precedence:

① Functions
② x^y, $x^{1/y}$, R→P, P→R
③ ×, ÷, //
④ +, −

(① to ③: Except in BASE-N mode)

Operations with the same precedence are performed from left to right, with operations enclosed in parentheses performed first. If parentheses are nested, the operations enclosed in the innermost set of parentheses are performed first.

Registers L_1 through L_6 are provided to store operations of lower precedence (including parenthetical operations). Since six registers are provided, calculations up to six levels can be retained (3 levels in the IMP mode).
Since each level can contain up to three open parentheses, parentheses can be nested up to 18 times (9 maximum in the IMP mode).

Example (4 levels, 5 nested parentheses)

Operation

$\underbrace{2\,\times}_{\text{1 level}}\ \underbrace{(\,(\,(\,3\,+}_{\text{1 level}}\ \underbrace{4\,\times}_{\text{1 level}}\ \underbrace{(\,(\,5\,+}_{\text{1 level}}\ \underset{\text{A}}{\uparrow}\,4\,)\,\div\,3\,)\,)$

$\div\,5\,)\,+\,9\,)\,=$

Register contents at point A.

x	4
L_1	((5+
L_2	4×
L_3	(((3+
L_4	2×
L_5	
L_6	

■ Making Corrections

If you notice an input mistake before you press the arithmetic operation key, simply press C to clear the value and enter it again.
In a series of calculations, you can correct errors in intermediate results by recalculating correctly when the error appears and then continuing with the original series from where you interrupted it.
You can also use the ▶ key to backspace through an entered value until you reach the digit you wish to change and then make any necessary corrections. For example:

To change entry of 123 to 124

124	124.
▶	12.
3	123.

If you make a mistake by pressing the wrong key when entering +, −, ×, ÷, SHIFT or SHIFT , simply press the appropriate key to correct. In this case, the most recently pressed key operation is used, but it retains the order of precedence of the original operation entered.

■ About Overflows and Errors

When predetermined calculation ranges are exceeded, the calculator will display the indicator "−E−" or "−C−" at the right of the display and disable any further calculation. This will occur in the following cases:

1. If an intermediate result (arithmetic, scientific functions, statistical) or a value stored in a memory exceeds $\pm(9.999999999 \times 10^{99})$. Values stored in memory prior to the overflow are retained.
2. If a function calculation exceeds the input range shown on page 87.
3. If an error is made in operation during standard deviation calculation (i.e. calculation of $\bar{x}$ or σn when $n = 0$).
4. If the ranges for any of the number systems used in the BASE-N mode are exceeded.
   *In these cases above, the "−E−" symbol appears. Press the AC key to clear the error and start again from the beginning.
5. If the cumulative number of parentheses levels, arithmetic levels (including x^y and $x^{1/y}$) exceeds 6, or if the number of open parentheses exceeds 18.
   *In this case, the "−C−" symbol appears on the display. Press the C key to clear the error and display the value immediately preceding generation of the error.
   *Continue operation using a calculation that doesn't cause a level overflow.
   *Another method for clearing such an error is to press the AC key and start again from the beginning.

6/PERFORMING BASIC CALCULATIONS

You can perform basic calculations in the RUN mode ([MODE] [.]) and the COMP mode ([MODE] [0]).

■ Arithmetic Operations

Enter arithmetic operations just as they are written, from left to right.

Example	Operation	Display
23+4.5−53=−25.5	23 [+] 4.5 [−] 53 [=]	−25.5
56×(−12)÷(−2.5)=268.8	56 [×] 12 [+/−] [÷] 2.5 [+/−] [=]	268.8
* To enter a negative value, press [+/−] after you enter the value.		
12369×7532×74103=	12369 [×] 7532 [×]	
$6.903680613 \times 10^{12}$	74103 [=]	6.903680613^{12}
(=6903680613000)		
1.23÷90÷45.6=	1.23 [÷] 90 [÷] 45.6 [=]	2.997076023^{-04}
$2.997076023 \times 10^{-4}$ (=0.0002997076023)		
* Exponential notation is used for values that are 10^{10} (100-million) or greater, or less than 10^{-2} (0.01).		
$(4.5 \times 10^{75}) \times (-2.3 \times 10^{-78})=$	4.5 [EXP] 75 [×] 2.3 [+/−] [EXP] 78 [+/−] [=]	−0.01035
$-0.01035 = -10.35 \times 10^{-3}$	(Exponential notation) [ENG]	-10.35^{-03}
* Exponential notation is not used for values that fall between 10^{-2} and 10^{10}. Use the [ENG] key (page 12) if you want to specify scientific notation.		
$(3 \times 10^5) \div 7 = 42857.14286$	3 [EXP] 5 [÷] 7 [=]	42857.14286
$(3 \times 10^5) \div 7 - 42857 = 0.1428571$	(Continuing) [−] 42857 [=]	0.1428571

* Calculations are performed using a 12-digit mantissa, and results are rounded off to 10 digits. The original 12 digits, however, is retained internally. In the case of 10, 11, and 12-digit values, 001 ~ 007 is cut off, while 993 ~ 999 are rounded up, meaning that both cases result in 000.

• Mixed Arithmetic Calculations

Multiplication and division are given precedence over addition and subtraction.

Example	Operation	Display
3+5×6=33	3 [+] 5 [×] 6 [=]	33.
7×8−4×5=36	7 [×] 8 [−] 4 [×] 5 [=]	36.
1+2−3×4÷5+6=6.6	1 [+] 2 [−] 3 [×] 4 [÷] 5 [+] 6 [=]	6.6.

■ Specifying the Number of Decimal Places and the Number of Significant Digits

Specify the number of decimal places (FIX) by the operation [MODE] [7] [n], where n is a value from 0 through 9.
Specify the number of significant digits (SCI) by the operation [MODE] [8] [n], where n is a value from 0 through 9. In the case of the SCI, 0 is regarded as 10.
The specifications you make for FIX and SCI are retained until you change them with a new specification, or you clear them by [MODE] [9].
No matter what you specify for FIX and SCI, calculations within the calculator are always performed using a 12-digit mantissa. If you want to make internal and displayed value equal, press [SHIFT] [RND].
You can also move the decimal place of a displayed value three places to the left and right by using the [ENG] key.

Example	Operation	Display
100÷6=16.66666666········	100 [÷] 6 [=]	16.66666667
	(Specifies 4 decimal places.) [MODE] [7] [4]	16.6667
	(Clears the specification.) [MODE] [9]	16.66666667
	(Specifies 5 significant digits.) [MODE] [8] [5]	1.6667^{01}
	(Clears the specification.) [MODE] [9]	16.66666667
* Both the FIX and SCI specifications can be changed at any time, even during a calculation sequence.		
	(Specifies 3 decimal places.) [MODE] [7] [3]	0.000
200÷7×14=400	200 [÷] 7 [=]	28.571
	(Continuing with the internal 12-digit value) [×] 14 [=]	400.000
	Rounds off the internal value to the FIX specification.	
	200 [÷] 7 [=]	28.571
	(Internal rounding) [SHIFT] [RND] [×] 14 [=]	399.994
	(Clears the specification.) [MODE] [9]	399.994
123m×456=56088m	123 [×] 456 [=]	56088.
=56.088km	[ENG]	56.088^{03}
78g×0.96=74.88g	78 [×] 0.96 [=]	74.88
=0.07488kg	[SHIFT] [ENG]	0.07488^{03}

■ Using Parentheses

Parentheses can be nested up to 6 levels, 18 pairs (page 17).

Example	Operation	Display
$100-(2+3)\times4=80$	100[−][(]2[+]3[)]	5.
	(Continuing) [×]4[=]	80.
$(2+3)\times(4+5)=45$	2[+]3[)][×][(]4[+]5[=]	45.
* You may omit the first open parenthesis and the close parenthesis immediately preceding the [=] key.		
$10-\{2+7\times(3+6)\}=-55$	10[−][(]2[+]7[×][(]3[+]6[=]	−55.
$\{(2+3)\times4-(5+6)\times3\}\times2=-26$	2[+]3[)][×]4[−] [(]5[+]6[)][×]3[)][×]2[=]	−26.
$\frac{2\times3+4}{5}=(2\times3+4)\div5=2$	2[×]3[+]4[)][÷]5[=]	2.
* In the above example, pressing [=] produces results identical to those obtained by [)].		
$\frac{2}{3}\left(\frac{8}{10}-\frac{1}{2}\right)=0.2$	2[÷]3[×] [(]8[÷]10[−]1[÷]2[)][=]	0.2
$\frac{5\times6+6\times8}{15\times4+12\times3}=0.8125$ $=(5\times6+6\times8)\div(15\times4+12\times3)$	[(]5[×]6[+]6[×]8[)][÷] [(]15[×]4[+]12[×]3[)][=]	0.8125
* For complex fractions, distinguish the upper numerator from the denominator by including all of the values in parentheses.		
$(1.2\times10^{19})-\{(2.5\times10^{20})\times\frac{3}{100}\}=4.5\times10^{18}$	1.2[EXP]19[−][(]2.5[EXP]20[×] 3[÷]100[)][=]	4.5^{18}
$\frac{6}{4\times5}=0.3$	4[×]5[÷]6[SHIFT][X↔Y][=] Register exchange	0.3
* Another operation: 6[÷][(]4[×]5[)][=] or 6[÷]4[÷]5[=].		

■ Using Constants

Pressing any of the arithmetic operation keys twice (or any other even number of times) registers the currently displayed value as a constant. Then, each press of the [=] key performs the arithmetic operation using the constant.

Example	Operation	Display
$12\underline{+23}=35$	23[+][+]12[=]	35.
$45\underline{+23}=68$	45[=]	68.
$(-78)\underline{+23}=-55$	78[+/−][=]	−55.
$7\underline{-5.6}=1.4$	5.6[−][−]7[=]	1.4
$2.9\underline{-5.6}=-2.7$	2.9[=]	−2.7
$(8.5\times10^{3})\underline{-5.6}=8494.4$	8.5[EXP]3[=]	8494.4
$2.3\underline{\times12}=27.6$	12[×][×]2.3[=]	27.6
$(-4.56)\underline{\times12}=-54.72$	4.56[+/−][=]	−54.72
$0.6\underline{\times12}=7.2$	0.6[=]	7.2
$78\underline{\div9.6}=8.125$	9.6[÷][÷]78[=]	8.125
$(1.2\times10^{15})\underline{\div9.6}=1.25\times10^{14}$	1.2[EXP]15[=]	1.25^{14}
$45\underline{\div9.6}=4.6875$	45[=]	4.6875
$\underline{3\times6\times}9=162$	3[×]6[×][×]9[=]	162.
$\underline{3\times6\times}8=144$	8[=]	144.
$\underline{3\times6\times}(5+6)=198$	[(]5[+]6[)][=]	198.
$17+17+17+17=68$	17[+][+][=][=][=]	68.
$50-3.6-3.6-3.6=39.2$	3.6[−][−]50[=][=][=]	39.2
$\{(1.1^{3})^{2}\}^{2}=3.138428377$	1.1[×][×][=][=]	1.331
	[×][=][×][=]	3.138428377
$\frac{56}{4\times(2+3)}=2.8$	4[×][(]2[+]3[)][÷][÷]	20.
	56[=]	2.8
* [÷][÷] and [−][−] have the same result as the register exchange function (page 21).		

■ Performing Memory Calculations

Your scientific calculator is equipped with a single ***independent memory*** that is controlled using the [Min], [M+], [M−], and [MR] keys. It also has six ***constant memories*** that are controlled using the [Kin], [Kout], and [1] ~ [6] keys.
Both the independent and constant memories are ***non-volatile***, which means that they retain their contents even when the calculator is switched off by the Auto Power OFF function.

■ Using the Independent Memory

The independent memory is extremely handy when you wish to accumulate the results of different multiple operations.

Example	Operation	Display
23+9=32	23 [+] 9 [=] [SHIFT] [Min]	32.
53−6=47	53 [−] 6 [M+]	47.
−) 45×2=90	45 [×] 2 [SHIFT] [M−]	90.
99÷3=33	99 [÷] 3 [M+]	33.
(Total) 22	[MR]	22.

*Use [SHIFT] [Min] to input the first value to the independent memory. Also, as in the above example, [M+] and [M−] perform the function of the [=] key, besides accumulating values in memory. The operation [SHIFT] [M−] is identical to [+/-] [M+].

Example	Operation	Display
7+7+7+(2×3)+(2×3)	7 [SHIFT] [Min] [M+] [M+] 2 [×] 3 [M+] [M+]	
+(2×3)−(2×3)=33	[M+] [SHIFT] [M−] [MR]	33.
45×6=270	6 [×] [×] 45 [=] [SHIFT] [Min]	270.
−) 12×6= 72	12 [SHIFT] [M−]	72.
78×6=468	78 [M+]	468.
(Total) 666	[MR]	666.
7×4×12.3=344.4	7 [×] 4 [×] 12.3 [SHIFT] [Min] [=]	344.4
−12.3×(8+5)=−159.9	[MR] [+/-] [×] [(] 8 [+] 5 [)] [=]	−159.9
(12.3+6)×9=164.7	[(] [MR] [+] 6 [)] [×] 9 [=]	164.7

■ Using Constant Memories

The six constant memories are identified as K_1 through K_6. These memories can be used to store such values as data, constants and results.
You can perform arithmetic operations within a K register by pressing [Kin], followed by the desired arithmetic operation, and then a register specification ([1] ~ [6]).

- Constant memories can be used in the BASE-N mode by pressing [Kin] after the [SHIFT] key.
- Constant memories cannot be used in the IMP mode.

Example	Operation	Display
193.2÷23=8.4	193.2 [Kin] [1] [÷] 23 [=]	8.4
193.2÷28=6.9	[Kout] [1] [÷] 28 [=]	6.9
193.2÷42=4.6	[Kout] [1] [÷] 42 [=]	4.6

*The above example can use the independent memory.
193·2 [SHIFT] [Min] [÷] 23 [=], [MR] [÷] 28 [=], [MR] [÷] 42 [=]

Example	Operation	Display
$\frac{9\times6+3}{(7-2)\times8}=1.425$	9 [×] 6 [+] 3 [=] [Kin] [1]	57.
	[(] 7 [−] 2 [)] [×] 8 [=] [Kin] [2]	40.
	[Kout] [1] [÷] [Kout] [2] [=]	1.425

*The above example separates (9 × 6 + 3) and (7 − 2) × 8 into their own memories, and then performs the final calculation using the contents of the memories.

Example	Operation	Display
7×8×9=504	7 [Kin] [1] [×] 8 [Kin] [2] [×] 9 [Kin] [3] [=] [SHIFT] [Min]	504.
4×5×6=120	4 [Kin] [+] [1] [×] 5 [Kin] [+] [2] [×] 6 [Kin] [+] [3] [M+]	120.
3×6×9=162	3 [Kin] [+] [1] [×] 6 [Kin] [+] [2] [×] 9 [Kin] [+] [3] [M+]	162.
Total 14 19 24 786	[Kout] [1]	14.
Adds to constant memory 4.	[Kout] [2]	19.
	[Kout] [3]	24.
	[MR]	786.

*[−], [×], and [÷] can also be used within the K registers in the same way.

Example	Operation	Display
12×(2.3+3.4)−5=63.4	12 [×] [(] 2.3 [+] 3.4 [)] [Kin] [1] [−] 5 [=]	63.4
30×(2.3+3.4+4.5)−15×4.5=238.5	30 [×] 4.5 [Kin] [+] [1] [SHIFT] [X↔K] [1]	
	To exchange the displayed number (4.5) with the contents of constant memory 1.	
	[−] 15 [×] [Kout] [1] [=]	238.5

■ Entering Engineering Exponents

You can enter engineering exponents in the COMP mode ([MODE] [0]) and the IMP mode ([MODE] [2]). Note the following:

Operation	Unit	Unit Symbol	Operation	Unit	Unit Symbol
[SHIFT] [1]	10^{-12}	p (Pico)	[SHIFT] [4]	10^{-3}	m (Milli)
[SHIFT] [2]	10^{-9}	n (Nano)	[SHIFT] [5]	10^{3}	k (Kilo)
[SHIFT] [3]	10^{-6}	μ (Micro)	[SHIFT] [6]	10^{6}	M (Mega)

If you specify an engineering exponent after you have already entered an exponent or after you have previously entered a different engineering exponents, only the exponent value changes.

Example

2•5 [EXP] 12 [SHIFT] [4] → $2{\cdot}5^{-03}$
(2.5^{12})

If you enter an engineering exponent immediately following the [AC] key or while a calculation result is displayed, a mantissa of 1 is automatically used.

Example

[AC] [SHIFT] [3] → $1.^{-06}$

Immediately after you have entered an engineering exponent, you can change it by simply entering the new exponent.

Example

5 [SHIFT] [6] → $5.^{06}$
(continuing from above.) [0] [7] → $5.^{07}$

You can enter engineering exponents even in a program.

Example	Operation	Display
123×456×7.8m(Milli)	123 [×] 456 [×]	56088.
=437.4864	7.8 [SHIFT] [4]	7.8^{-03}
	[=]	437.4864
100k (Kilo)×5μ (Micro) =0.5	100 [SHIFT] [5] [×] 5 [SHIFT] [3] [=]	0.5

7 / PERFORMING BINARY, OCTAL, DECIMAL AND HEXADECIMAL CALCULATIONS

You can perform binary, octal, decimal, and hexadecimal calculations and conversions in the RUN mode ([MODE] [•]) and the BASE-N mode ([MODE] [1]). You can specify the type of value you are entering by using [BIN] for binary, [OCT] for octal, [DEC] for decimal, and [HEX] for hexadecimal.

- Calculation Ranges
  Note the following limitations for each of the number systems:

Binary (10 digits)	Positive	: $0 \leqq x \leqq 111111111$
	Negative	: $1000000000 \leqq x \leqq 1111111111$
Octal (10 digits)	Positive	: $0 \leqq x \leqq 3777777777$
	Negative	: $4000000000 \leqq x \leqq 7777777777$
Decimal (10 digits)	Positive	: $0 \leqq x \leqq 2147483647$
	Negative	: $-2147483648 \leqq x \leqq -1$
Hexadecimal (8 digits)	Positive	: $0 \leqq x \leqq$ 7FFFFFFF
	Negative	: $80000000 \leqq x \leqq$ FFFFFFFF

- Numbers Used in Each System
  The following shows the numbers you can use with each number system. You will not be able to even enter any other number (i.e. it is impossible to enter a 5 when using binary). In hexadecimal, the letters B and D will appear on the display in lower case to avoid confusion with similar looking values.

Binary : 0, 1
Octal : 0, 1, 2, 3, 4, 5, 6, 7
Decimal : 0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Hexadecimal : 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F

■ Performing Binary/Octal/Decimal/Hexadecimal Conversions

Example	Operation	Display
	[MODE] [1] BASE-N specification	
22_{10} conversion to binary	[DEC] 22 [BIN]	10110.^{b}
conversion to octal	[OCT]	26.^{o}
conversion to hexadecimal	[HEX]	16.^{H}
513_{10} conversion to binary	[DEC] 513 [BIN]	−E−^{b}

* Sometimes it is impossible to convert from a number system with a large range to a system with a smaller range.

Example	Operation	Display
$7FFFFFF_{16}$ conversion to decimal	[HEX] 7FFFFFF [DEC]	134217727.^{d}
4000000000_8 conversion to decimal	[OCT] 4000000000 [DEC]	−536870912.^{d}
123_{10} conversion to octal	[DEC] 123 [OCT]	173.^{o}
1100110_2 conversion to decimal	[BIN] 1100110 [DEC]	102.^{d}

■ Expressing Negative Values

You can convert the currently displayed value to its negative equivalent by pressing the [NEG] key. Negatives for binary, octal, and hexadecimal are expressed using their two's complement.

Example	Operation	Display
	[MODE] [1] BASE-N specification	
Negative of 1010_2	[BIN] 1010 [NEG]	1111110110.^{b}
Conversion to decimal	[DEC]	−10.^{d}
Negative of 1_2	[BIN] 1 [NEG]	1111111111.^{b}
Negative of 2_8	[OCT] 2 [NEG]	7777777776.^{o}
Negative of 34_{16}	[HEX] 34 [NEG]	FFFFFFCC.^{H}

■ Performing Binary/Octal/Decimal/Hexadecimal Calculations

You can use memory calculations, parenthetical operations, and constants for calculations in any of the number systems.

Example	Operation	Display
	[MODE] [1] BASE-N specification	
$10111_2 + 11010_2 = 110001_2$	[BIN] 10111 [+] 11010 [=]	110001.^{b}
$123_8 \times ABC_{16} = 37AF4_{16}$	[OCT] 123 [×] [HEX] ABC [=]	37AF4.^{H}
$= 228084_{10}$	[DEC]	228084.^{d}
$1F2D_{16} - 100_{10} = 7881_{10}$	[HEX] 1F2D [−] [DEC] 100 [=]	7881.^{d}
$= 1EC9_{16}$	[HEX]	1EC9.^{H}
$7654_8 \div 12_{10} = 334.3\cdots\cdots_{10}$	[OCT] 7654 [÷] [DEC] 12 [=]	334.^{d}
$= 516_8$	[OCT]	516.^{o}
*Decimal portions are cut off.		
$110_2 + 456_8 \times 78_{10} \div 1A_{16}$	[BIN] 110 [+] [OCT] 456 [×]	
$= 390_{16}$	[DEC] 78 [÷] [HEX] 1A [=]	390.^{H}
$= 912_{10}$	[DEC]	912.^{d}
*Multiplication and division are given precedence over addition and subtraction in mixed calculations.	[HEX] BC [×]	
$BC_{16} \times (14_{10} + 69_{10}) = 15604_{10}$	[(] [DEC] 14 [+] 69 [)] [=]	15604.^{d}
$= 3CF4_{16}$	[HEX]	3CF4.^{H}
$\underline{23_8} + 963_{10} = 982_{10}$	[OCT] 23 [SHIFT] [Min] [+] [DEC] 963 [=]	982.^{d}
$\underline{23_8} + 101011_2 = 111110_2$	[MR] [+] [BIN] 101011 [=]	111110.^{b}
$2A56_{16} \times \underline{23_8} = 32462_{16}$	[HEX] 2A56 [×] [MR] [=]	32462.^{H}
$\underline{2B_{16} \times} CD_{16} = 226F_{16}$	[HEX] 2B [×] [×] CD [=]	226F.^{H}
$\underline{2B_{16} \times} 58_{10} = 2494_{10}$	[DEC] 58 [=]	2494.^{d}
$\underline{2B_{16} \times} 63_8 = 4221_8$	[OCT] 63 [=]	4221.^{o}

*[+], [−], and [÷] constant calculations are performed as described on page 22.

8/USING FUNCTIONS IN CALCULATIONS

You can perform function calculations in the RUN mode ([MODE] [·]) and the COMP mode ([MODE] [0]). Function calculations are performed by first entering a value and pressing the key for the desired function.
Function calculations can be used in series with other functions and arithmetic operations, and with parentheses.
See page 87 for details on input pages and accuracy.

■ Using Trigonometric and Inverse Trigonometric Functions

Example	Operation	Display
14°25'36" = 14.42666667°	14 [°'"] 25 [°'"] 36 [°'"]	14.42666667
12.3456° = 12°20'44.16"	12.3456 [SHIFT] [←°'"]	12°20°44.16

* If the total number of digits required for degrees, minutes and seconds exceed eight, the higher order digits (degrees and minutes) are displayed, while the lower order (right side) digits are not. The entire value is retained internally as a decimal value.

Example	Operation	Display
sin63°52'41" = 0.897859012	[MODE] [4] → "D" 63 [°'"] 52 [°'"] 41 [°'"] [sin]	0.897859012
$\cos\left(\frac{\pi}{3}\text{rad}\right)=0.5$	[MODE] [5] → "R" [π] [÷] 3 [=] [cos]	0.5
tan(−35grad) = −0.612800788	[MODE] [6] → "G" 35 [+/-] [tan]	−0.612800788
2·sin45°×cos65° = 0.597672477	"D" 2 [×] 45 [sin] [×] 65 [cos] [=]	0.597672477
$\sin^{-1}0.5=30°$	"D" [·] 5 [SHIFT] [sin⁻¹]	30.
$\cos^{-1}\frac{\sqrt{2}}{2}=0.785398163\text{rad}$	"R" 2 [√] [÷] 2 [=] [SHIFT] [cos⁻¹]	0.785398163
$=\frac{\pi}{4}\text{rad}$	(Continuing) [÷] [π] [=]	0.25
$\tan^{-1}0.741=36.53844577°$	"D" [·] 741 [SHIFT] [tan⁻¹]	36.53844577
= 36°32'18.4"	(Continuing) [SHIFT] [←°'"]	36°32°18.4
$2.5\times(\sin^{-1}0.8-\cos^{-1}0.9)$ = 68°13'13.53"	"D" 2.5 [×] [(] [·] 8 [SHIFT] [sin⁻¹] [−] [·] 9 [SHIFT] [cos⁻¹] [)] [=] [SHIFT] [←°'"]	68°13°13.53

■ Using Logarithmic and Exponential Functions

Example	Operation	Display
$\log 1.23(=\log_{10}1.23)=0.089905111$	1.23 [log]	0.089905111
$\ln 90(=\log_e 90)=4.49980967$	90 [ln]	4.49980967
log456÷ln456 = 0.434294481	456 [SHIFT] [Min] [log] [÷] [MR] [ln] [=]	0.434294481
$10^{1.23}=16.98243652$ (To determine the antilogarithm of common logarithm 1.23)	1.23 [SHIFT] [10^x]	16.98243652
$e^{4.5}=90.0171313$ (To determine the antilogarithm of natural logarithm 4.5)	4.5 [SHIFT] [e^x]	90.0171313
$10^4\cdot e^{-4}+1.2\cdot 10^{2.3}=422.5878667$	4 [SHIFT] [10^x] [×] 4 [+/-] [SHIFT] [e^x] [+] 1.2 [×] 2.3 [SHIFT] [10^x] [=]	422.5878667
$5.6^{2.3}=52.58143837$	5.6 [SHIFT] [x^y] 2.3 [=]	52.58143837
$123^{\frac{1}{7}}(=\sqrt[7]{123})=1.988647795$	123 [SHIFT] [$x^{1/y}$] 7 [=]	1.988647795
$4^{\underline{2.5}}=32$	2.5 [SHIFT] [x^y] [SHIFT] [x^y] 4 [=]	32.
$0.16^{\underline{2.5}}=0.01024$	[·] 16 [=]	0.01024
$9^{\underline{2.5}}=243$	9 [=]	243.

*Constant calculations for x^y and $x^{1/y}$ are performed using the same procedures as those used for the arithmetic operations.

Example	Operation	Display
$(78-23)^{-12}=1.305111829\times10^{-21}$	[(] 78 [−] 23 [)] [SHIFT] [x^y] 12 [+/-] [=]	1.305111829⁻²¹
$2+\underline{3\times\underline{64^{\frac{1}{3}}}}-4=10$	2 [+] 3 [×] 64 [SHIFT] [$x^{1/y}$] 3 [−] 4 [=]	10.
$2^2+3^3+4^4=287$	2 [SHIFT] [x^y] 2 [+] 3 [SHIFT] [x^y] 3 [+] 4 [SHIFT] [x^y] 4 [=]	287.

$10^{5.1}+9^{5.1}+e^{5.1}=$ 199615.7293	5.1 [SHIFT] [x^y] [SHIFT] [x^y] 10 [=] [SHIFT] [Min] 9 [M+] 1 [SHIFT] [e^x] [M+] [MR]	199615.7293
(The above is identical to 5.1 [SHIFT] [10^x] [+] 9 [SHIFT] [x^y] 5.1 [+] 5.1 [SHIFT] [e^x] [=])		
$2\times3.4^{(5+6.7)}=3306232.001$	2 [×] 3.4 [SHIFT] [x^y] [(] 5 [+] 6.7 [)] [=]	3306232.001
log sin40°+log cos35° =−0.278567983	[MODE] [4] → "D" 40 [sin] [log] [+] 35 [cos] [log] [=]	−0.278567983
Antilogarithm is 0.526540784 (Calculation of the logarithm of sin40° × cos35°)	(Continuing) [SHIFT] [10^x]	0.526540784

■ Using Hyperbolic and Inverse Hyperbolic Functions

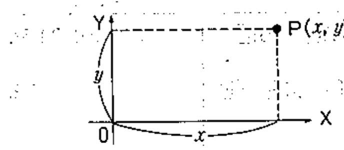
Example	Operation	Display
sinh3.6=18.28545536	3.6 [hyp] [sin]	18.28545536
tanh2.5=0.986614298	2.5 [hyp] [tan]	0.986614298
cosh2.5−sinh2.5=0.082084998	2.5 [SHIFT] [Min] [hyp] [cos] [−]	6.13228948
$=e^{-2.5}$	[MR] [hyp] [sin] [=]	0.082084998
(Proof of $\cosh x \pm \sinh x = e^{\pm x}$)	(Continuing) [ln]	−2.5
$\sinh^{-1}30=4.094622224$	30 [SHIFT] [hyp] [$\sin^{-1}$]	4.094622224
$\cosh^{-1}\left(\frac{20}{15}\right)=0.795365461$	20 [÷] 15 [=] [SHIFT] [hyp] [$\cos^{-1}$]	0.795365461
To calculate x when tanh $4x$ = 0.88		
$x=\frac{\tanh^{-1}0.88}{4}=0.343941914$	[·] 88 [SHIFT] [hyp] [$\tan^{-1}$] [÷] 4 [=]	0.343941914
$\sinh^{-1}2\times\cosh^{-1}1.5=$ 1.389388923	2 [SHIFT] [hyp] [$\sin^{-1}$] [×] 1.5 [SHIFT] [hyp] [$\cos^{-1}$] [=]	1.389388923

■ Other Functions ($\sqrt{\ }$, $1/x$, x^2, $\sqrt[3]{\ }$, RAN#)

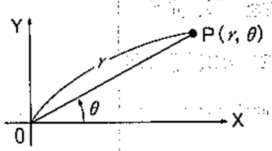
Example	Operation	Display
$\sqrt{2}+\sqrt{5}=3.65028154$	2 [√] [+] 5 [√] [=]	3.65028154
$\frac{1}{\frac{1}{3}-\frac{1}{4}}=12$	3 [$1/x$] [−] 4 [$1/x$] [=] [$1/x$]	12.
$2^2+3^2+4^2+5^2=54$	2 [SHIFT] [x^2] [+] 3 [SHIFT] [x^2] [+] 4 [SHIFT] [x^2] [+] 5 [SHIFT] [x^2] [=]	54.
$\sqrt[3]{36\times42\times49}=42$	[(] 36 [×] 42 [×] 49 [)] [SHIFT] [$\sqrt[3]{\ }$]	42.
Random number generation (pseudo-random number in the range of 0 ~ 0.999)	[SHIFT] [RAN#]	(Ex.) 0.570
$\sqrt{13^2-5^2}+\sqrt{3^2+4^2}=17$	[(] 13 [SHIFT] [x^2] [−] 5 [SHIFT] [x^2] [)] [√] [+]	12.
	[(] 3 [SHIFT] [x^2] [+] 4 [SHIFT] [x^2] [)] [√] [=]	17.
$\sqrt{1-\sin^2 40°}=0.766044443$ =cos40°	"D" 1 [−] 40 [sin] [SHIFT] [x^2] [=] [√]	0.766044443
(Proof of $\cos\theta = \sqrt{1-\sin^2\theta}$)	(Continuing) [SHIFT] [$\cos^{-1}$]	40.

■ Using Coordinate Conversion (R→P, P→R)

• **Rectangular coordinates**



• **Polar coordinates**



The value of θ in R→P can be determined in the range of $-180° < \theta \leqq 180°$. The same true for both radians and grads.

Example	Operation	Display
To calculate r and $\theta°$ when x = 14 and y = 20.7	"D" 14 [SHIFT] [R→P] 20.7 [=]	24.98979792 (r)
	(Continuing) [SHIFT] [X↔Y] [SHIFT] [←°'"]	55°55°42.2 (degrees, minutes, seconds)
To calculate r and θ rad when x = 7.5 and y = −10	"R" 7.5 [SHIFT] [R→P] 10 [+/−] [=]	12.5(r)
	(Continuing) [SHIFT] [X↔Y]	−0.927295218 (rad)
To calculate x and y when r = 25 and θ = 56°	"D" 25 [SHIFT] [P→R] 56 [=]	13.97982259 (x)
	(Continuing) [SHIFT] [X↔Y]	20.72593931 (y)
To calculate x and y when r = 4.5 and θ = 2/3π rad	"R" 4.5 [SHIFT] [P→R] [(] 2 [÷] 3 [×] [π] [)] [=]	−2.25(x)
	(Continuing) [SHIFT] [X↔Y]	3.897114317(y)

■ Performing Percent Calculations

Percent calculations cannot be performed in the BASE-N mode and IMP mode.

Example	Operation	Display
• **Percent** To calculate 17% of 1,500cc.		
$1500\times\frac{17}{100}=255$(cc)	1500 [×] 17 [SHIFT] [%]	255.
• **Add-on** To calculate 620g increased by 15%.		
$620+620\times\frac{15}{100}=713$(g)	620 [×] 15 [SHIFT] [%] [+]	713.
• **Discount** To calculate 7.53V decreased by 4%.		
$7.53-7.53\times\frac{4}{100}=7.2288$(V)	7.53 [×] 4 [SHIFT] [%] [−]	7.2288
• **Ratio** To calculate what percent of 9.6m is 7.8m.		
$\frac{7.8}{9.6}\times100=81.25$(%)	7.8 [÷] 9.6 [SHIFT] [%]	81.25
• **Rate of change** To calculate what percent of the original is the resulting quantity if 300g is added to 500g.		
$\frac{300+500}{500}\times100=160$(%)	300 [+] 500 [SHIFT] [%]	160.
To calculate the percent increase if temperature rises from 40°C to 46°C.		
$\frac{46-40}{40}\times100=15$(%)	46 [−] 40 [SHIFT] [%]	15.

• Percent Constants		
To calculate 15% of 1500g	1500 ×× 15 SHIFT %	225.
To calculate 23% of 1500g	(Continuing) 23 SHIFT %	345.
To calculate what percent of 192g is 30g.	192 ÷÷ 30 SHIFT %	15.625
To calculate what percent of 192g is 12g.	12 SHIFT %	6.25
To calculate what percent of the original is the resulting quantity if 600g is added to 1200g.	1200 ++ 600 SHIFT %	150.
To calculate what percent of the original is the resulting quantity if 510g is added to 1200g.	510 SHIFT %	142.5
To calculate the percentage decrease from 150g to 138g.	150 −− 138 SHIFT %	−8.
To calculate the percentage increase from 150g to 168g.	168 SHIFT %	12.

9/PERFORMING STATISTICAL CALCULATIONS

Perform statistical calculations in the RUN mode (MODE ·). Before entering the statistical data, you should clear the memory by pressing SHIFT AC. Remember, the memories are not cleared when the calculator is switched off by the Auto Power OFF function.

■ Performing Standard Deviation Calculations

Press MODE 3 and confirm that the "SD" indicator is shown on the display.
Enter each data item, using the following operation:
DATA DATA — Enter negative values using +/−
Repeat as many times as necessary to input all of the data.

Example: 50 +/− DATA (inputs −50 as data)

You can also enter identical data items by pressing the DATA key repeatedly, or by using a multiplication operation.

Example: Data: 41, 41
41 DATA DATA
Data: 57, 57, 57, 57, 57, 57, 57, 57
57 × 8 DATA

• Standard Deviation Formulas

The following formulas are used for standard deviation:

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

(For population standard deviation when all of the data for a limited population are input.)

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

(For sample standard deviation using a sample from a population to estimate the standard deviation for the entire population.)

• Mean formula

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

Example	Operation	Display
Data: 55, 54, 51, 55, 53, 53, 54, 52	[MODE] [3] [SHIFT] [KAC] 55 [DATA] 54 [DATA] 51 [DATA] 55 [DATA] "SD" 53 [DATA] [DATA] 54 [DATA] 52 [DATA]	52.
	(Standard deviation σ_n) [SHIFT] [σ_n]	1.316956719
• The same results can be obtained no matter in what sequence they are recalled.	(Standard deviation σ_{n-1}) [SHIFT] [σ_{n-1}]	1.407885953
	(Mean $\bar{x}$) [SHIFT] [$\bar{x}$]	53.375
	(Number of data n) [Kout] [n]	8.
	(Sum Σx) [Kout] [Σx]	427.
	(Sum of squares Σx^2) [Kout] [Σx^2]	22805.
To calculate the unbiased variance and the difference between the mean and each data item.	(Continuing) [SHIFT] [σ_{n-1}] [SHIFT] [x^2]	Unbiased variance 1.982142857
	[SHIFT] [$\bar{x}$] [−] [−] 55 [=]	1.625 (55 − $\bar{x}$)
	54 [=]	0.625 (54 − $\bar{x}$)
	51 [=]	−2.375 (51 − $\bar{x}$)
	⋮	⋮
What is $\bar{x}$ and σ_{n-1} for the following table?	[SHIFT] [KAC] 110 [×] 10 [DATA]	110.
	130 [×] 31 [DATA]	130.
	150 [×] 24 [DATA]	150.
	170 [DATA] [DATA]	170.
	190 [DATA] [DATA] [DATA]	190.
	[Kout] [n]	70.
	[SHIFT] [$\bar{x}$]	137.7142857
	[SHIFT] [σ_{n-1}]	18.42898069

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

■ Correcting and Deleting Entered Data

① To delete 50 [DATA] which you have just entered: [SHIFT] [DEL]
② To delete 49 [DATA] which you previously entered: 49 [SHIFT] [DEL]
③ To clear 51 [×] which you have just entered: [AC]
④ To clear 120 [×] 31 which you have just entered: [AC]
⑤ To clear 120 [×] 30 [DATA] which you previously entered: 120 [×] 30 [SHIFT] [DEL]

10/PERFORMING IMPEDANCE CALCULATIONS

Enter the impedance calculation (IMP) mode by pressing [MODE] [2], causing the indicator "IMP" to appear on the display. Entering the IMP mode automatically clears the contents of all of the constant memories.
You should note here that these memories cannot be used for constants in the IMP mode.
The IMP mode makes it possible for you to perform complex number calculations and composite impedance calculations. When the result of a calculation in the IMP mode is a complex number, the real part will be displayed along with the symbol "⇀". This symbol indicates that an imaginary part also exists.
When you wish to view the imaginary part of the result, you press [illegible] or [SHIFT] [illegible]. The indicator "j" will be on the display when the imaginary part of the result is shown. To go back to the real part of the result, press [illegible] or [SHIFT] [illegible] again.
When the result of the calculation is a pure imaginary number (real part is zero), the imaginary part is displayed immediately.

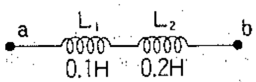
■ Composite Impedance Calculations

If you press the [f/n] key immediately after you enter a value, the value you entered is treated as a frequency. Keep this in mind, because if you then try to perform complex number calculations, you will only get an error.
Next, if you press [SHIFT] [f/n], the frequency will be recalled from memory.

■ Calculating Coil Impedance

If you press the [ℓ] key after entering a value, or at some point during a calculation, the calculation proceeds assuming that the displayed value represents inductance (L[H]). If you try to perform this calculation on a complex number, you will get an error.
Calculation for the [ℓ] key is performed according to the formula $j\ (2\pi f L)$, so the result is an imaginary number.

Example:



$Z = j\omega L_1 + j\omega L_2$

To determine the composite impedance between a and b when f = 50Hz.

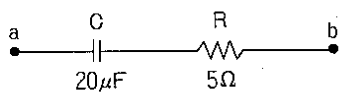
[MODE] [2] (IMP mode)

Operation	Display
50 [f/Hz] (To input as a frequency)	IMP D 50.
[·] 1 [ωL]	IMP D j 31.41592654
[+] [·] [2] [ωL]	IMP D j 62.83185307
[=]	IMP D j 94.24777961 ← Impedance

■ Calculating Capacitor Impedance

If you press the [⊣⊢] key after entering a value, or at some point during a calculation, the calculation proceeds assuming that the displayed value represents electrostatic capacitance (C[F]). You cannot perform this calculation for a complex number. Calculation for the [⊣⊢] key is performed according to the formula $^1/_j\ (2\pi fC)$, so the result is an imaginary number.

Example:



$Z = 1/j\omega C + R$

To determine the composite impedance between a and b when f = 60Hz.

[MODE] [2] (IMP mode)

Operation	Display
60 [f/Hz] (To input as a frequency)	IMP D 60.
20 [SHIFT] [3 μ]	IMP D 20.$^{-06}$
[⊣⊢]	IMP D j −132.6291192
[+] 5 [=]	IMP D 5. ← Real part
[Re⇔Im]	IMP D ←j −132.6291192 ← Imaginary part

■ Calculating Parallel Circuit Impedance

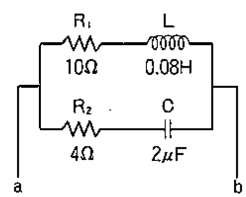
If you press the [//] key after entering a value, or at some point during a calculation, the calculation proceeds assuming that the displayed value represents capacitance of a parallel circuit. In this case, you can perform this calculation for both real and imaginary numbers.
The [//] key can be used in both the COMP mode and SD mode.

Entering a [//] b [=] calculates $\dfrac{a \times b}{a + b}$

Example:

2 [//] 3 [=] $\rightarrow \dfrac{2 \times 3}{2 + 3} = \dfrac{6}{5} = 1.2$

Example:



$Z = (R_1 + j\omega L) // (R_2 + 1/j\omega C)$

To determine the composite impedance between a and b when f = 50Hz.

MODE 2 (IMP mode)

Key operation	Display
50 f/in (To input as a frequency)	50.
(10 + ⊡ 08 ∠	25.3274123
) //	10.
(4 + 2 SHIFT ∠ ⊣⊢	−1591.549431
)	4.
=	10.32390233 ← Real part
Re⇔Im	25.46925453 ← Imaginary part

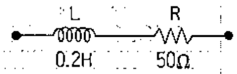
■ Calculating Angular Frequency ω, Angle of Deviation θ, and Absolute Value |Z|

Press SHIFT ω (after entering a value for f using the f/in key) to calculate the angular frequency $\omega = 2\pi f$.

If you press the θ key after entering a value, or at some point during a calculation, the angle of deviation for the displayed complex number (composite impedance) is calculated. The result is calculated according to the current angle mode setting (DEG, RAD, GRA). $|\theta| \leq 180°$ (DEG), $|\theta| \leq \pi$ (RAD), $|\theta| \leq 200$ (GRA)

If you press the |Z| key after entering a value, or at some point during a calculation, the absolute value for the displayed complex number (composite impedance) is calculated.

Example:



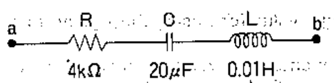
To calculate the angular frequency ω, angle of deviation θ, and absolute value |Z| for a 0.2H coil (L), 50-ohm resistor (R), and a frequency of 60Hz (f).

MODE 2 (IMP mode)

Key operation	Display
60 f/in (To input as a frequency)	60.
SHIFT ω (Angular frequency ω calculation)	376.9911184 ← ω
⊡ 2 ∠ +	75.39822369
50 = SHIFT Min	50.
θ (Angle of deviation θ calculation)	56.44982741 ← θ
MR	50.
|Z| (Absolute value |Z| calculation)	90.47039369 ← |Z|

■ Calculation Examples of Composite Impedance

• Serial Circuit

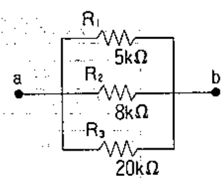


$Z = R + 1/j\omega C + j\omega L$

To determine the composite impedance between *a* and *b* when f = 50Hz.

Operation	Display
[MODE] [2] (IMP mode)	
50 [f/n] (To enter as a frequency)	50.
4 [SHIFT] [5] [+] 20 [SHIFT] [3] [⊣⊢]	−159.1549431
[+] 0.01 [L]	3.141592654
[=]	4000. ← Real part
[Re↔Im]	−156.0133504 ← Imaginary part

• Parallel circuit



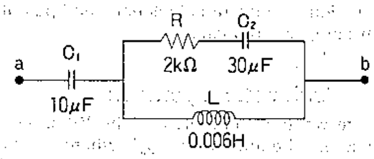
$$Z = \frac{1}{\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}}$$

To determine the composite impedance between *a* and *b*.

Operation	Display
[MODE] [2] (IMP mode)	
5 [SHIFT] [5] [//]	5000.
8 [SHIFT] [5] [//]	3076.923077
20 [SHIFT] [5] [=]	2666.666667 ← Z

* This example can also be performed in the COMP mode or SD mode.

• Mixed circuit



$$Z = 1/j\omega C_1 + \frac{1}{\frac{1}{1/j\omega C_2 + R} + \frac{1}{j\omega L}}$$

To determine the composite impedance between *a* and *b* when f = 50Hz.

Operation	Display
[MODE] [2] (IMP mode)	
50 [f/n] (To input as a frequency)	50.
10 [SHIFT] [3] [⊣⊢]	−318.3098862
[+] [((] [(] 2 [SHIFT] [5] [+]	2000.
30 [SHIFT] [3] [⊣⊢]	−106.1032954
[)] [//]	2000.
0.006 [L]	1.884955592
[)] [=]	1.771717931^{-03} ← Real part
[Re↔Im]	−316.4248383 ← Imaginary part

■ Using Complex Numbers in Calculations

Arithmetic operations, memory calculations, constant calculations and parenthetical calculations are all possible with complex numbers.

■ Using Complex Numbers in Arithmetic Operations

Input arithmetic operations as they are written, from left to right. When entering complex numbers, however, you should use the format "$x + yj$", where x is the real part and y is the imaginary part. In this case, enter "j" using the operations [SHIFT] [j].

Example	Operation	Display
	[MODE] [2] (IMP)	
$(2+3j)+(4+5j)$	2 [+] 3 [SHIFT] [j] [+] 4 [+] 5 [SHIFT] [j] [=]	6.
$=6+8j$	[Re↔Im]	8. j
$(5+4j)-(7-2j)$	5 [+] 4 [SHIFT] [j] [−] [(] 7 [−] 2	
$=-2+6j$	[SHIFT] [j] [)] [=]	−2.
	[Re↔Im]	6. j
$(2+j)\times(2-j)$	[(] 2 [+] 1 [SHIFT] [j] [)] [×] [(] 2	
$=5$	[−] 1 [SHIFT] [j] [)] [=]	5.
$(-3+j)\div(1+2j)$	[(] 3 [+/-] [+] 1 [SHIFT] [j] [)] [÷]	
$=-0.2+1.4j$	[(] 1 [+] 2 [SHIFT] [j] [)] [=]	−0.2
	[Re↔Im]	1.4 j

■ Using Complex Numbers in Memory Calculations

You can add complex numbers to the independent memory using [M+] and subtract them using [SHIFT] [M−]. The symbol "M" appears on the display whenever the independent memory contains both or either of the real part and the imaginary part.
If you enter 0 using [SHIFT] [Min], both the real and imaginary parts are cleared from memory.
You can recall values stored in memory using the [MR] key. Even when you recall a value from memory, it is still retained, so you can recall it as many times as you wish.
An error is generated whenever the value stored in memory exceeds the allowable range. Even though an error occurs, the contents of the memory are retained.
When you change from the IMP mode to any other mode, the imaginary part of the value stored in memory is cleared, but the real part is retained. Remember, you can only use the independent memory in the IMP mode.
You cannot use the constant memories.

Example	Operation	Display
$(6+4j)+(2-3j)$	[MODE] [2] (IMP)	
$=8+j$	[AC] [SHIFT] [Min] 6 [+] 4 [SHIFT] [j] [+] 2	
	[−] 3 [SHIFT] [j] [=]	8.
	[SHIFT] [Min] [Re↔Im]	1. j
$(-3+2j)-(3+j)$	[(] 3 [+/-] [+] 2 [SHIFT] [j] [)] [−] [(]	
$=-6-j$	3 [+] 1 [SHIFT] [j] [)] [=]	−6.
	[M+] [Re↔Im]	1. j
$-)(2+3j)\times(5-4j)$	[(] 2 [+] 3 [SHIFT] [j] [)] [×] [(] 5	
$=22+7j$	[−] 4 [SHIFT] [j] [)] [=]	22.
	[SHIFT] [M−] [Re↔Im]	7. j
$(4+2j)\div(1+j)$	[(] 4 [+] 2 [SHIFT] [j] [)] [÷] [(] 1	
$=3-j$	[+] 1 [SHIFT] [j] [)] [=]	3.
	[M+] [Re↔Im]	−1. j
(Total) $-17-6j$	[MR]	−17.
	[Re↔Im]	−6. j

■ Using Complex Numbers in Constant Calculations

Though the constant memories are not available in the IMP mode, you can still perform one type of constant calculations. Just as with standard arithmetic calculations, pressing an arithmetic operation keys twice (or some other even number of times) makes the displayed value a constant. You should note, however, that complex numbers do not have an power calculation function, so if you try to used [x^y] and [$x^{1/y}$] in constant calculations, you will generate an error.

Example	Operation	Display
$(2+3j)+(5+4j)$	[(] 2 [+] 3 [SHIFT] [j] [)] [+] [+] [(] 5	
$=7+7j$	[+] 4 [SHIFT] [j] [)] [=]	7.
	[Re↔Im]	7. $^{-j}$
$(2+3j)+(-4+2j)$	[(] 4 [+/-] [+] 2 [SHIFT] [j] [)] [=]	-2.
$=-2+5j$	[Re↔Im]	5. $^{-j}$
$(2+3j)+(7-3j)$	[(] 7 [-] 3 [SHIFT] [j] [)] [=]	9.
$=9$		

■ Other Complex Number Calculations

In the IMP mode, parentheses can be used up to three levels and nine pairs. Pressing [SHIFT] [X↔Y] exchanges the contents of the X register with those of the Y register. If you enter [SHIFT] [1/x], the calculator will produce the inverse of the displayed complex number.

Example:
Inverse of $1-2j$

1 [-] 2 [SHIFT] [j] [=] [SHIFT] [1/x] → 0.2 [Re↔Im] → −0.4 $^{-j}$ → $0.2-0.4j$

Whenever you change the sign of a complex number, it is changed for both the real and imaginary parts.

Example:

1 [+] 2 [SHIFT] [j] [=] [+/-] → −1 [Re↔Im] → −2 $^{-j}$ → $-1-2j$

$(1+2j)$ $(-1-2j)$

Pressing [SHIFT] [RND] causes both the real and imaginary parts stored internally (Y register) to be cut off so as to be equal to the displayed value.

The following is a list of functions that will produce an error if you try to use them with complex numbers (though they are valid for the real part only).

sin cos tan $\sin^{-1}$ $\cos^{-1}$ $\tan^{-1}$ sinh cosh tanh $\sinh^{-1}$ $\cosh^{-1}$ $\tanh^{-1}$ log ln 10^x e^x x^y $x^{1/y}$ $\sqrt{\ }$ $\sqrt[3]{\ }$ x^2 R→P P←R °'''

11/USING BUILT-IN FORMULAS FOR CALCULATIONS

Your scientific calculator comes with 27 preprogrammed, built-in formulas. Just enter a number in the RUN mode ([SHIFT] [·]) and COMP mode ([MODE] [0]), and the formula you need appears.

Example:

To call up Formula 8 — Closed loop gain of operational amplifier inverting feed back circuit.

[SHIFT] [AC]	Clears variable contents
8 [FMLA] (Calls up Formula 8)	−08− Formula number selected appears on the display for about 0.5 second.
	FMLA D Z'? 0. Input standby display.

If you simply press the [FMLA] key without entering a formula number, the formula you last called up will be recalled. An error will occur if the value you enter for the formula number is not within the range of 1 through 27.

* Once execution of a formula begins, the data you enter for the variables are stored in the constant memories (K registers). Because of this, you should make it a habit to clear the constant memories by [SHIFT] [AC] before you execute a formula.
* You cannot perform built-in formula calculations in the BASE-N, SD, or IMP mode. You must use the COMP mode ([MODE] [0]).

Once you call up a formula, prompts will appear in succession on the display to guide you through the input. Enter the required values to get the result.

Example:

Closed loop gain of operational amplifier non-inverting feed back circuit.

[SHIFT] [FMLA] 9 [FMLA] (Calls up Formula 9)	FMLA D — Z'? 0.
1 0 [SHIFT] [5]	FMLA D — Z'? 10.03
[RUN] (Assigns 2 × 10^3 to variable Zf)	FMLA D — Z? 0.
1 [SHIFT] [5]	FMLA D — Z? 10.03
[RUN] (Assigns 10 × 10^3 [Ω] to variable Z)	FMLA D — V? 0.
1	FMLA D — V? 1.
[RUN] (Assigns 1 [V] to variable V)	FMLA D — V_1= 11.

• Re-executing formulas

Once you execute a formula that you have called up, you can execute it again by simply pressing [FMLA] or [RUN]. On the second execution, the values that you entered the first time for the variables are still assigned. You can change these variables as they appear, and then press the [RUN] key to re-execute the formula with the new values.

• Interrupting Formula Execution

Press the [AC] key to interrupt execution of a formula. At this time, the display will clear and the calculator will switch to the normal calculation mode.

• Clearing Errors Generated During Formula Execution

If an error occurs while you are entering values for a variables, press [AC] followed by [FMLA], and start again from the beginning. Note, however, that values that were successfully entered before the error are not cleared. If you wish to clear all of these values, press [SHIFT] [AC] and then [FMLA].

Should the error occur after all values are entered and actual calculations begin, first press [AC] to clear the error condition. Next, Press [FMLA] to start from the beginning. Again, values assigned to variables are not cleared by this operation.

• Reading the Display of Formula Results

Once execution of the formula is complete, the results appear on the display in the format: "variable = value". If more than one results were produced, you will have to press the [RUN] key to advance to the next variable.

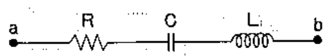
12/USING PROGRAMMED CALCULATIONS

Your scientific calculator has a 30-step capacity for storage of calculation formulas entered by you. Only one user formula can be contained in memory at any time. Entering your programmed calculation is as easy as performing the calculation in the LRN mode ([MODE] [EXP]). Once you do this, the calculator remembers the formula and you can recall it any time you like in the RUN mode ([MODE] [·]). Just as with built-in formulas, the calculator will ask you for the necessary data and perform the calculation for you automatically.

■ Programming a Formula

Example 1

To determine impedance Z between a and b in a serial circuit, for each of the values given for resistor R, inductance L, electrostatic capacitance C, and frequency f in the table below.



Resistor R [Ω]	Electrostatic capacitance [μF]	Inductance L [H]	Frequency f [Hz]
10	5	0.02	50
5	30	0.03	60

Formula Z=R+1/$j\omega$C+$j\omega$L

The following shows that key sequence required to input the required formula.

50 [f/in] 10 [+] 5 [SHIFT] [3] [⊣⊢] [+] 0.02 [ω]

↑ Value of f ↑ Value of R ↑ Value of C ↑ Value of L

[=] → Z (real part) [▶] → Z (imaginary part)

Operate the above sequence in the LRN mode ([MODE] [EXP]). Note that [ENT] must be pressed prior to data entry (the values of f, R, L and C in this case).

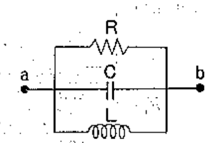
Operation	Display	
(Enter LRN mode) [AC] [MODE] [EXP]	LRN D Pro 0.	
(Enter IMP mode) [MODE] [2]	LRN IMP D Pro 0.	
[ENT] 50 [f/in]	LRN IMP D Pro 50.	
[ENT] 10	LRN IMP D Pro 10.	
[+]	LRN IMP D Pro 10.	
[ENT] 5	LRN IMP D Pro 5.	
[SHIFT] [3]	LRN IMP D Pro $5.^{-06}$	
[⊣⊢]	LRN IMP D Pro j −636.6197724	
[+]	LRN IMP D Pro~ 10.	
[ENT] 0.02	LRN IMP D Pro 0.02	
[ω]	LRN IMP D Pro j 6.283185307	
[=]	LRN IMP D Pro~ 10.	Result (real part)
[SHIFT] [BLT] [▶]	LRN IMP D Pro~j −630.3365871	Result (imaginary part)

● Sample execution using the programmed formula

(Enter RUN mode)	Display	
[MODE] [·] [AC]	IMP D 0.	
[RUN]	IMP D Pro 0.	
60 [RUN]	IMP D Pro 60.	
5 [RUN]	IMP D Pro 5.	
30 [SHIFT] [3] [RUN]	IMP D Pro~ 5.	
0.03 [RUN]	IMP D Pro~ 5.	Result (real part)
[RUN]	IMP D ~j −77.10967928	Result (imaginary part)

Example 2

To determine impedance Z between a and b in a parallel circuit, for each of the values given for resistor R, inductance L, electrostatic capacitance C, and frequency f in the table below.



Resistor R [Ω]	Electrostatic capacitance [μF]	Inductance L [H]	Frequency f [Hz]
47	1	0.03	60
4	100	0.01	60

Formula $Z=R /\!\!/ 1/j\omega C /\!\!/ j\omega L$

- The following shows that key sequence required to input the required formula.

60 [f in] 47 [//] 1 [SHIFT] [3] [-|+] [//] 0.03 [ω]

Value of f / Value of R / Value of C / Value of L

[=] → Z (real part) [Re↔Im] → Z (imaginary part)

Operation	Display	
(Enter LRN mode) [AC] [MODE] [EXP]	LRN Pro 0.	
(Enter IMP mode) [MODE] [2]	LRN IMP Pro 0.	
[ENT] 60 [f in]	LRN IMP Pro 60.	
[ENT] 47	LRN IMP Pro 47.	
[//]	LRN IMP Pro 47.	
[ENT] 1	LRN IMP Pro 1.	
[SHIFT] [3]	LRN IMP Pro 1.$^{-06}$	
[-|+]	LRN IMP Pro −2652.582385	
[//]	LRN IMP Pro 46.98524907	
[ENT] 0.03	LRN IMP Pro 0.03	
[ω]	LRN IMP Pro 11.30973355	
[=]	LRN IMP Pro 2.593390637	Result (real part)
[SHIFT] [HLT] [Re↔Im]	LRN IMP Pro 10.73143443	Result (imaginary part)

- Sample execution using the programmed formula

(Enter RUN mode)	Display	
[MODE] [·] [AC]	IMP Pro 0.	
[RUN]	IMP Pro 0.	
60 [RUN]	IMP Pro 60.	
4 [RUN]	IMP Pro 4.	
100 [SHIFT] [3] [RUN]	IMP Pro 3.91106409	
0.01 [RUN]	IMP Pro 2.187548966	Result (real part)
[RUN]	IMP 1.991186929	Result (imaginary part)

■ About Program Steps

The table below illustrates how the program data entered for Example 2 is stored by the calculator.

Step	Contents	Step	Contents
1	MODE 2	7	-|+
2	ENT	8	//
3	f in	9	ENT
4	ENT	10	ω
5	//	11	=
6	ENT	12	HLT
		13	Re↔Im

The program can have up to 30 steps, and only one program can be stored at one time. If you try to store more than 30 steps, an error will occur ("−E−" appears on the display), and further input will become impossible. At this time, press [AC] to clear the error.

Once you begin to execute a programmed calculation, it follows the sequence you programmed without stopping, until it reaches the end of the program. If you want to input variable data or check an intermediate result, you have to stop program execution using [ENT] or [SHIFT] [HLT].

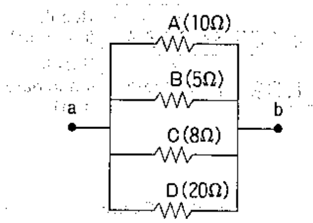
Note that each step contains one *function*. This means that a step can have multiple key operations that make up a function. The following keys of the calculator are all counted as one step (one function).

■ About Variable Names

When you are programming a calculation, you can enter the alphabetic letters A through F instead of ENT to act as variables. Then when you execute the calculation the calculator will prompt you for values for smoother calculations. Remember, however, that you cannot use variables in the IMP mode.

Example:

To determine the composite impedance between *a* and *b* in the circuit shown here, when A = 10 Ω, B = 5 Ω, C = 8 Ω, and D = 20 Ω.



Operation	Display
(Enter the LRN and COMP modes) MODE EXP MODE 0	LRN Pro 0.
ALPHA A	LRN Pro A? 0.
// ALPHA B	LRN Pro B? 0.
// ALPHA C	LRN Pro C? 0.
// ALPHA D	LRN Pro D? 0.
=	LRN Pro 0.

• Sample execution using the programmed formula

	Display	
(Enter RUN mode, clear K memories) MODE · AC SHIFT KAC	Pro 0.	
RUN	Pro A? 0.	
(Input A) 10 RUN	Pro B? 0.	
(Input B) 5 RUN	Pro C? 0.	
(Input C) 8 RUN	Pro D? 0.	
(Input D) 20 RUN	2.105263158	Result

* Variable names A through F correspond to constant memories K_1 through K_6. Therefore, any values stored in the constant memories will appear on the display when executions reaches the corresponding variable name. If a value appears, just change it to the value you wish to use in the execution.

■ Erasing program

To erase a program without entering a new program, enter the LRN mode using MODE EXP, and then press SHIFT PCL. Then you can return to the RUN mode by MODE ·. You can also enter the LRN mode and simply begin to program a new calculation. This will automatically erase any program that may already be there.

■ Specifying the Calculation Mode in the LRN Mode

Besides functions, you can also include binary, octal, decimal and hexadecimal calculations, in addition to standard deviation within programmed calculations. To do this, however, you must also specify the correct calculation mode within the program. To do this, perform the following operation:

Operation	Display
① MODE EXP (Enter LRN mode)	LRN Pro 0.
② MODE 1 (Specify BASE-N mode)	LRN BASE-N Pro 0.^{d}

The other modes can be specified using the same procedure.

■ Looping a Programmed Calculation

You can make execution of the programmed calculation loop back to the beginning and repeatedly execute by using a return instruction.

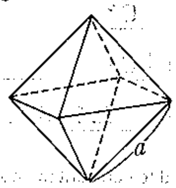
1. Unconditional return to the first step of program: RTN

Write the sequence of [SHIFT] [RTN] at the end of a program to execute it repeatedly.

Example:

Calculate the surface areas (S) of regular octahedrons whose ridges are respectively 10, 7 and 15 cm long.

Formula: $S = 2\sqrt{3}\,a^2$



Ridge length (a)	Surface area
10 cm	(346.41) cm^2
7	(169.74)
15	(779.42)

- The following sequence of key operations realizes a mathematical procedure of the above formula.

* Values enclosed with parentheses are to be obtained.

Operation:

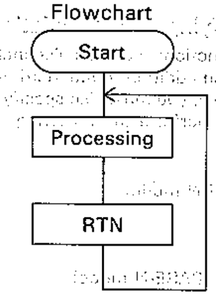
[MODE] [0] [PI]

[ENT] 10 [SHIFT] [x^2] [×] 2 [×] 3 [SHIFT] [√] [=] [SHIFT] [RTN]

↑ Value of a ↑ Return instruction

Step	Instruction
1	ENT
2	SHIFT x^2
3	×
4	2
5	×
6	3
7	SHIFT √
8	=
9	SHIFT RTN

Flowchart



Operation	Display
(Enter RUN mode) [AC] [MODE] [·]	0.
[RUN]	Pro 0. [ENT]
(When $a = 7$) 7 [RUN]	Pro 169.7409791 [ENT]
(When $a = 15$) 15 [RUN]	Pro 779.4228634 [ENT]

* If a program includes an RTN instruction but neither ENT nor HLT, the program will, once started, not stop in an endless loop. To stop the program in such a case, press [AC].

2. Return to the first step of program depending on the condition of the contents of the X register (display):

$x > 0$, $x \leqq M$

- $x > 0$: Return to the first step of program if the contents of the X register is greater than zero and go to the next step otherwise.
- $x \leqq M$: Return to the first step of program if the contents of the X register is equal to or smaller than the contents of the M register and otherwise go to the next step.

Example:

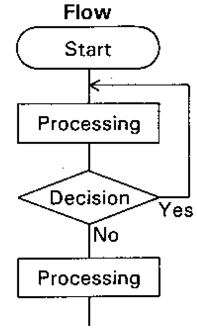
To determine the largest value among the following:
456, 852, 321, 753, 369, 741, 684, 643

[MODE] [EXP]

[ENT] [SHIFT] [$x\leqq$M] [SHIFT] [Min] [SHIFT] [RTN]

Step	Instruction	
1	ENT	
2	SHIFT $x \leqq$ M	Yes
3	SHIFT Min	No
4	SHIFT RTN	

Flow

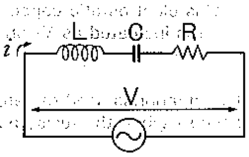


Operation		Display	
	[MODE] [·] [AC] [SHIFT] [Min]	0.	Clear independent memory
Data input	[RUN] 456 [RUN]	Pro 456.	
	852 [RUN]	Pro 852.	
	321 [RUN]	Pro 321.	
	⋮		
	643 [RUN]	Pro 643.	
	[MR]	Pro 852.	Largest value

13/FORMULA LIBRARY

1 Frequency of Electric Oscillation

$$f_0=\frac{1}{2\pi\sqrt{LC}} \quad (L,\ C>0)$$



L is self-inductance, C is electric capacity
f_0 is indicated as f_1 on the display.

• This equation is used to determine the harmonic oscillation frequency of a circuit when the self-inductance and electric capacity of the condensor are known.

Example

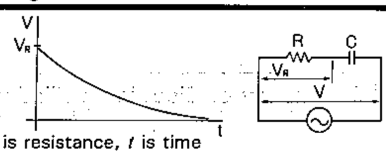
Determine the harmonic oscillation frequency of a circuit with self-inductance L = 60mH (60×10^{-3}H), and an electric capacity of C = 90μF (90×10^{-12}F).

	Operation	Display
(Recall frequency of electric oscillation.)	[SHIFT] [AC] 1 [FMLA]	FMLA D L? 0.
(Enter value for L.)	60 [SHIFT] [4] [RUN]	FMLA D C? 0.
(Enter value for C.)	90 [SHIFT] [1] [RUN]	FMLA D f_1 =68489.38267
	[ENG]	FMLA D f_1 =68.48938267 03

2 Change in Terminal Voltage of R in RC Series Circuit

$$V_R = V \cdot e^{-t/CR}$$

(C, R>0, t>0)



C is electrostatic capacity, R is resistance, t is time
V_R is indicated as V_1 on the display.

- This equation is used to determine voltage of terminal V_R in an RC series circuit at time t when the resistance and condenser capacity are known.

Example

Determine the voltage at terminal R in an RC circuit at time t = 10s when R = 1M ohm (1 × 10^6 ohms), C = 8μF (8 × 10^{-6}F), and V = 90V.
(When t = 0s, voltage of terminal V_R = 0V)

	Operation	Display
(Recall change in terminal voltage of R in RC series circuit.)	SHIFT AC 2 FMLA	V? 0.
(Enter value for V.)	90 RUN	t? 0.
(Enter value for t.)	10 RUN	C? 0.
(Enter value for C.)	8 SHIFT 3 RUN	R? 0.
(Enter value for R.)	1 SHIFT 6 RUN	V₁= 25.78543172

3 Time Constant for an RC Series Circuit

$$t = -CR\ell n\frac{V_R}{V} \qquad \left(\frac{V_R}{V}>0,\ C>0,\ R>0\right)$$

C is electrostatic capacitance, R is resistance, V_R is terminal voltage of R, V is terminal voltage between R and C.
V_R is indicated as V_1 on the display.

- This equation is used to determine the time constant for an RC series circuit when the terminal voltage of R, resistance value and condenser capacitance are known.

Example

Determine the time constant for a series circuit when resistance R = 1MΩ (1 × 10^{-6}Ω), electrostatic capacitance C = 8μF (8 × 10^{-6}F), and terminal voltage of V = 90V, and V_R = 30V).

	Operation	Display
(Recall time constant for an RC series circuit.)	SHIFT AC 3 FMLA	C? 0.
(Enter value for C)	8 SHIFT 3 RUN	R? 0.
(Enter value for R)	1 SHIFT 6 RUN	V₁? 0.
(Enter value for V_R)	30 RUN	V? 0.
(Enter value for V)	90 RUN	t= 8.788898309

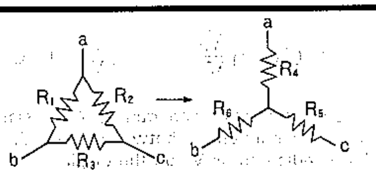
4 Δ → Y conversion

$$R_4=\frac{R_1R_2}{R_1+R_2+R_3}$$

$$R_5=\frac{R_2R_3}{R_1+R_2+R_3}$$

$$R_6=\frac{R_3R_1}{R_1+R_2+R_3}$$

$(R_1, R_2, R_3 > 0)$



R_1, R_2 and R_3 are indicated as r, r' and r respectively.
R_4, R_5 and R_6 are indicated as R, R' and R respectively.

- This equation is used to convert from a Δ connection to a Y connection.

Example

Determine the R_4, R_5, R_6 values for a Y connection based upon a Δ connection of $R_1=35$ ohms, $R_2=90$ ohms, $R_3=50$ ohms.

	Operation	Display
(Recall Δ → Y conversion.)	SHIFT KAC 4 FMLA	r ? 0.
(Enter value for R_1.)	35 RUN	r'? 0.
(Enter value for R_2.)	90 RUN	r ? 0.
(Enter value for R_3.)	50 RUN	R = 18.
	RUN	R'= 25.71428571
	RUN	R = 10.

5 Y → Δ Conversion

$$R_1=\frac{R_4R_5+R_5R_6+R_6R_4}{R_5}\qquad R_3=\frac{R_4R_5+R_5R_6+R_6R_4}{R_4}$$

$$R_2=\frac{R_4R_5+R_5R_6+R_6R_4}{R_6}$$

$(R_4, R_5, R_6 > 0)$

R_1, R_2 and R_3 are indicated as r, r' and r respectively.
R_4, R_5 and R_6 are indicated as R, R' and R respectively.

- This equation is used to convert from a Y connection to a Δ connection.

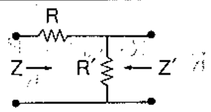
Example

Determine the R_1, R_2, R_3 values for a Δ connection based upon a Y connection of $R_4=20$ ohms, $R_5=30$ ohms, $R_6=50$ ohms.

	Operation	Display
(Recall Y → Δ conversion.)	SHIFT KAC 5 FMLA	R ? 0.
(Enter value for R_4.)	20 RUN	R' ? 0.
(Enter value for R_5.)	30 RUN	R ? 0.
(Enter value for R_6.)	50 RUN	r = 103.3333333
	RUN	r'= 62.
	RUN	r = 155.

6 Resistance of Matched Impedance

$$R = Z\sqrt{1-\frac{Z'}{Z}} \qquad R' = \frac{Z'}{\sqrt{1-\frac{Z'}{Z}}}$$



Z and Z' are impedance $(Z \geq Z' > 0)$

- This equation is used to determine R and R' to match Z and Z' with minimum loss.

Example

Determine the R and R' when Z = 500 ohms and Z' = 200 ohms.

	Operation	Display
(Recall resistance of matched impedance)	SHIFT KAC 6 FMLA	FMLA D Z ? 0.
(Enter value for Z.)	500 RUN	FMLA D Z'? 0.
(Enter value for Z'.)	200 RUN	FMLA D R= 387.2983346
	RUN	FMLA D R'= 258.1988897
(L is a dummy.)	RUN	FMLA D L= 7.44253053

7 Power Factor

$$\theta = \cos^{-1}\frac{R}{Z} \qquad \left(\frac{R}{Z} \geq 0\right)$$

R is resistance, Z is impedance

- This equation is used to determine the power factor and lag angle* for an AC circuit when its resistance and impedance are known.

* lag angle: expresses phase delay of electric current in relation to electromotive force.

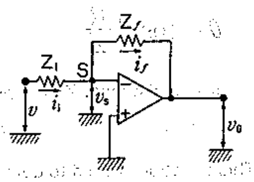
Example

Determine the lag angle for an AC circuit with a resistance of R = 12 ohms and impedance of Z = 16 ohms.

	Operation	Display
(Degree)	MODE 4	
(Recall power factor.)	SHIFT KAC 7 FMLA	FMLA D R? 0.
(Enter value for R.)	12 RUN	FMLA D Z? 0.
(Enter value for Z.)	16 RUN	FMLA D θ= 41.40962211

8 Closed Loop Gain of an Operational Amplifier Inverting Feed Back Circuit

$$v_0 = -\frac{Z_f}{Z_1} v \qquad \left(\frac{Z_f}{Z_1} > 0\right)$$



Z_1 is input impedance, Z_f is output impedance, v is input voltage, v_0 is output voltage
Z_1, v_0, Z_f are indicated as Z, v_1, Z' respectively on the display.

- This equation is used to determines the output voltage for an inverting feed back circuit when the input impedance, output impedance, and input voltage are known.

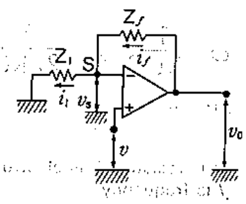
Example

Determine output voltage v_0 when input impedance Z_f = 10 k ohm, output impedance Z = 100 k ohm, and input voltage v = 1V.

	Operation	Display
(Recall closed loop gain of an operational amplifier invarting feed back circuit.)	SHIFT KAC 8 FMLA	FMLA D Z'? 0.
(Enter value for Z_f)	100 SHIFT ▭ RUN	FMLA D Z? 0.
(Enter value for Z_1)	10 SHIFT ▭ RUN	FMLA D V? 0.
(Enter value for v)		FMLA D V₁= −10

9 Closed Loop Gain of an Operational Amplifier Non-inverting Feed Back Circuit

$$v_0 = \left(1 + \frac{Z_f}{Z_1}\right) v \qquad \left(\frac{Z_f}{Z_1} > 0\right)$$



Z_1 is input impedance, Z_f is output impedance, v is input voltage, v_0 is output voltage
Z_1, v_0, Z_f are indicated as Z, v_1, Z' respectively on the display.

- This equation is used to determines the output voltage for a non-inverting feed back circuit when the input impedance, output impedance, and input voltage are known.

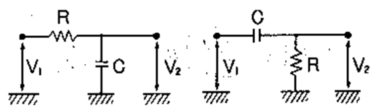
Example

Determine output voltage v_0 when input impedance Z_f = 1 k ohm, output impedance Z = 10 k ohm, and input voltage v = 10V.

	Operation	Display
(Recall closed loop gain of an operational amplifier non-inverting feed back circuit.)	SHIFT KAC 9 FMLA	FMLA D Z'? 0.
(Enter value for Z_f)	10 SHIFT ▭ RUN	FMLA D Z? 0.
(Enter value for Z_1)	1 SHIFT ▭ RUN	FMLA D V? 0.
(Enter value for v)	10 RUN	FMLA D V₁= 110.

10 Primary Filter

$$\omega=\frac{1}{RC},\quad f=\frac{1}{2\pi RC}$$



$(R>0,\ C>0)$

R is resistor, C is electrostatic capacitance, ω is angular frequency, f is frequency

• This equation is used to determines the angular frequency and frequency for a primary filter when resistor and electrostatic capacitance are known.

Example

Determine angular frequency ω and frequency f when resistor R = 10 k ohm, and electrostatic capacitance C = 0.002 μF.

	Operation	Display
(Recall primary filter.)	[SHIFT] [KAC/AC] 1 0 [FMLA]	R? 0.
(Enter value for R)	1 0 [SHIFT] [k/5] [RUN]	C? 0.
(Enter value for C)	0.002 [SHIFT] [μ/3] [RUN]	ω= 50000.
	[RUN]	f= 7957.747155

11 Voltage Gain

$$G(dB)=20\log_{10}\left(\frac{E'}{E}\right)(dB)\quad (E'/E>0)$$

E is input voltage, E' is output voltage

• This equation is used to determine the voltage gain of an amplifier circuit when the input voltage and output voltage are known.

Example

Determine the voltage gain for an input voltage of E = 15V and an output voltage of E' = 36V.

	Operation	Display
(Recall voltage gain.)	[SHIFT] [KAC/AC] 1 1 [FMLA]	E'? 0.
(Enter value for E'.)	36 [RUN]	E? 0.
(Enter value for E.)	15 [RUN]	G=7.604224834

12 Power Gain

$$G(dB) = 10 \log_{10}\left(\frac{P'}{P}\right)(dB) \quad (P'/P > 0)$$

P is input power, P' is output power

- This equation is used to determine the power gain of an amplifier circuit when the input power and output power are known.

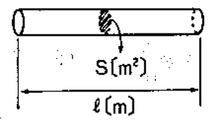
Example

Determine the power gain for an input power of P = 40mW (40×10^{-3}W) and an output power of P' = 5W.

	Operation	Display
(Recall power gain.)	SHIFT KAC 12 FMLA	P' FMLA D 0.
(Enter value for P'.)	5 RUN	P FMLA D 0.
(Enter value for P.)	40 SHIFT m 4 RUN	FMLA D G=20.96910013

13 Resistance of a Conductor

$$R = \rho \frac{\ell}{S} \quad (S, \ell, \rho > 0)$$



ℓ is length of conductor, S is cross sectional area of conductor, ρ is resistance of material from which conductor is formed

- This equation is used to determine the resistance of a conductor when the length and cross sectional area, as well as the resistance of the material from which the conductor is made are known.

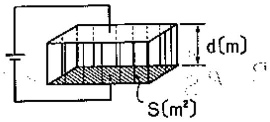
Example

Determine the resistance of copper wire for a length of ℓ = 20m and cross sectional area of S = 1.6mm² (1.6×10^{-6}m²). (The resistance of copper wire is $\rho = 1.72 \times 10^{-8}$ ohm • m.)

	Operation	Display
(Recall resistance of a conductor.)	SHIFT KAC 13 FMLA	p? FMLA D 0.
(Enter value for ρ.)	1.72 EXP 8 +/- RUN	l ? FMLA D 0.
(Enter value for ℓ.)	20 RUN	S ? FMLA D 0.
(Enter value for S.)	1.6 EXP 6 +/- RUN	R= FMLA D 0.215

14 Electrostatic Capacity between Parallel Plates

$$C=\varepsilon\frac{S}{d} \quad (S,\ d>0)$$



ε is dielectric constant, S is area of parallel plates, d is distance between parallel plates

• This equation is used to determine the electrostatic capacity stored between parallel plates when the dielectric constant of the material used in the plates, the area of parallel plates and the distance between the plates are known.

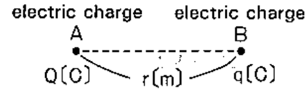
Example

Determine the electrostatic capacity stored between parallel plates with a dielectric constant of 2, when the area of the plates is $S=50\text{cm}^2$ ($50\times10^{-4}\text{m}^2$), and the distance between the two plates is $d=2$ cm (2×10^{-2}m).
Permittivity of vacuum (ε_0) $=8.854187818\times10^{-12}\text{Fm}^{-1}$

	Operation	Display
(Recall electrostatic capacity between parallel plates.)	[SHIFT] [KAC/AC] 14 [FMLA]	FMLA D ε ? 0.
(Enter value for ε.)	2 [×] 8.854187818 [EXP] 12 [+/-] [RUN]	FMLA D S ? 0.
(Enter value for S.)	50 [EXP] 4 [+/-] [RUN]	FMLA D d ? 0.
(Enter value for d.)	2 [EXP] 2 [+/-] [RUN]	FMLA D C=4.427093909^{-12}

15 Coulomb's Law

$$F=\frac{1}{4\pi\varepsilon_0}\,\frac{Qq}{r^2} \quad (r>0)$$



Q and q are sizes of two electric charges, r is distance between charges, ε_0 is permittivity.

• This equation is used to determine the motive force between two electric charges when the size of the charges and the distance between them are known.

Example

Determine the motive force between two electric charges of sizes $Q=3\times10^{-5}$ C (Coulombs) and $q=2\times10^{-5}$ C, with a distance of $r=0.5$m between the charges.

	Operation	Display
(Recall Coulomb's law.)	[SHIFT] [KAC/AC] 15 [FMLA]	FMLA D Q ? 0.
(Enter value for Q.)	3 [EXP] 5 [+/-] [RUN]	FMLA D q ? 0.
(Enter value for q.)	2 [EXP] 5 [+/-] [RUN]	FMLA D r ? 0.
(Enter value for r.)	0.5 [RUN]	FMLA D F=21.57012429

16 Joule's Law (1)

$$P = VI$$

V is potential difference, I is current

- This equation is used to determine the Joule's heat generated by a wire when the potential difference of the wire and the current are known.

Example

Determine the Joule's heat generated when a voltage of V = 100V and current of I = 4 amperes are applied to an electric heater.

	Operation	Display
(Recall Joule's law (1).)	SHIFT KAC 16 FMLA	V? 0.
(Enter value for V)	100 RUN	I? 0.
(Enter value for I)	4 RUN	P= 400.

17 Joule's Law (2)

$$P = RI^2 \qquad (R > 0)$$

R is resistance, I is current

- This equation is used to determine the Joule heat generated by a conductor when the resistance of the conductor and the current are known.

Example

Determine the Joule heat generated when an electric current of I = 20 amperes flows through a copper wire of resistance $R = 1.7 \times 10^{-4}$ ohms.

	Operation	Display
(Recall Joule's law (2).)	SHIFT KAC 17 FMLA	R? 0.
(Enter value for R.)	1.7 EXP 4 +/- RUN	I? 0.
(Enter value for I.)	20 RUN	P= 0.068

18 Joule's Law (3)

$$P=\frac{V^2}{R} \qquad (R>0)$$

V is electric potential difference, R is resistance

- This equation is used to determine the Joule heat generated by a conductor when its resistance and electric potential difference are known.

Example

Determine the Joule heat generated when an electric potential difference of V = 100V is applied to a copper wire of resistance $R = 1.1 \times 10^{-2}$ ohms.

	Operation	Display
(Recall Joule's law (3).)	SHIFT KAC 18 FMLA	U? 0.
(Enter value for V.)	100 RUN	R? 0.
(Enter value for R.)	1.1 EXP 2 +/- RUN	P= 909090.9091

19 Energy Stored in Electrostatic Capacity (1)

$$W=\frac{1}{2}QV$$

Q is capacity of electricity, V is potential difference

- This equation is used to determine the energy stored in a conductor when the capacity of electricity stored in the conductor and the potential difference are known.

Example

Determine the energy stored in a conductor with for a capacity of electricity $Q = 1.2 \times 10^{-5}$C and potential difference of V = 70V.

	Operation	Display
(Recall energy stored in electrostatic capacity (1).)	SHIFT KAC 19 FMLA	Q? 0.
(Enter value for Q.)	1.2 EXP 5 +/- RUN	U? 0.
(Enter value for V.)	70 RUN	W= 4.2-04

20 Energy Stored in Electrostatic Capacity (2)

$$W=\frac{1}{2}CV^2$$

C is electrostatic capacity, V is electric potential difference

- This equation is used to determine the energy stored in a conductor when the electrostatic capacity and electric potential difference of the conductor are known.

Example

Determine the energy stored in a conductor with an electrostatic capacity of C = 6μF, and an electric potential difference of V = 700V.

	Operation	Display
(Recall energy stored in electrostatic capacity (2).)	SHIFT KAC 20 FMLA	C? FMLA D 0.
(Enter value for C.)	6 SHIFT μ RUN	V? FMLA D 0.
(Enter value for V.)	700 RUN	W= FMLA D 1.47

21 Energy Stored in Electrostatic Capacity (3)

$$W=\frac{1}{2}\frac{Q^2}{C} \quad (C>0)$$

C is electrostatic capacity, Q is quantity of electricity

- This equation is used to determine the energy stored in a conductor when the quantity of electricity stored in the conductor and the electrostatic capacity are known.

Example

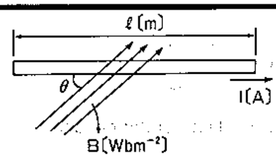
Determine the energy stored in a conductor for a quantity of electricity $Q=4\times10^{-7}$C and electrostatic capacity of C = 1.6μF.

	Operation	Display
(Recall energy stored in electrostatic capacity (3).)	SHIFT KAC 21 FMLA	Q? FMLA D 0.
(Enter value for Q.)	4 EXP 7 +/- RUN	C? FMLA D 0.
(Enter value for C.)	1.6 SHIFT μ RUN	W= FMLA D 5.$^{-08}$

22 Magnetic Force

$$F = IB\ell \sin\theta$$

$(B,\ \ell > 0,\ 0° \leq |\theta| \leq 90°)$



F is motive force of conductor, I is current flowing through conductor, B is magnetic flux density, ℓ is length of conductor, θ is angle formed by conductor and magnetic field.

- This equation is used to determine the motive force for a current flowing in a conductor which is caused within a magnetic field of uniform magnetic flux density.

Example

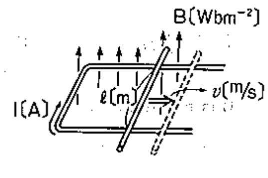
Determine the motive force of a conductor when a current of I = 4A flows through a conductor of length ℓ = 1.2m. The angle between the conductor and a uniform magnetic field with a magnetic flux density of B = 0.7 T is θ = 30 degrees.

	Operation	Display
(Degree)	[MODE] [4]	
(Recall magnetic force.)	[SHIFT] [KAC/AC] 22 [FMLA]	I? FMLA D 0.
(Enter value for I.)	4 [RUN]	B? FMLA D 0.
(Enter value for B.)	0.7 [RUN]	l? FMLA D 0.
(Enter value for ℓ.)	1.2 [RUN]	θ? FMLA D 0.
(Enter value for θ.)	30 [RUN]	F= FMLA D 1.68

23 Induced Electromotive Force

$$V_e = vB\ell \quad (v,\ B,\ \ell > 0)$$

v is motive velocity of conductor,
B is magnetic flux density,
ℓ is length of conductor
V_e is indicated as V on the display.



- This equation is used to determine induced electromotive force when the velocity, magnetic flux of the magnetic field and conductor length are known when the conductor is moved within a magnetic field.

Example

Determine the electric potential difference generated at both ends of a conductor of length ℓ = 1m when the conductor is moved through a magnetic field of $B = 0.2 \times 10^{-4}\ \frac{N}{Am}$ at a speed of v = 12m/s.

	Operation	Display
(Recall induced electromotive force.)	[SHIFT] [KAC/AC] 23 [FMLA]	V? FMLA D 0.
(Enter value for v.)	12 [RUN]	B? FMLA D 0.
(Enter value for B.)	0.2 [EXP] 4 [+/-] [RUN]	l? FMLA D 0.
(Enter value for ℓ.)	1 [RUN]	V= FMLA D 2.4⁻⁰⁴

24 Lorentz Force

$$F = Bqv \qquad (B > 0)$$

B is magnetic flux density, q is electronic charge, v is velocity

- This equation is used to determine the Lorentz force at which particles are moving within a magnetic field when the magnetic flux density of the field, as well as the electronic charge and velocity of the particles are known.

Example

Determine the Lorentz force when particles with an electronic charge of $q = 1.602 \times 10^{-19}$C are moving at a velocity of $v = 1 \times 10^6$m/s through a magnetic field with a magnetic flux density of $B = 0.5$Wb/m^2.

	Operation	Display
(Recall Lorentz force.)	SHIFT KAC 24 FMLA	B? 0.
(Enter value for B)	0.5 RUN	q? 0.
(Enter value for q)	1.602 EXP 19 +/- RUN	v? 0.
(Enter value for v)	1 EXP 6 RUN	F= 8.01^{-14}

25 Force Exerting on Magnetic Pole

$$F = mH \qquad (m, H > 0)$$

m is magnetic charge, H is magnetic field strength

- This equation is used to determine the strength of a magnetic pole when the magnetic charge and magnetic field strength are known.

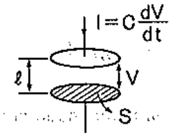
Example

Determine the strength of a magnetic pole for a magnetic charge of $m = 2$ ampere-turn/m, and a magnetic field strength of $H = 3 \times 10^{-3}$ Wb (Weber).

	Operation	Display
(Recall force exerting on magnetic pole.)	SHIFT KAC 25 FMLA	m? 0.
(Enter value for m.)	2 RUN	H? 0.
(Enter value for H.)	3 EXP 3 +/- RUN	F= 6.$^{-03}$

26 Energy Density Stored in Electrostatic Field

$$W=\frac{1}{2}\varepsilon E^2 \qquad (\varepsilon,\ E>0)$$



E is electric field, ε is permittivity

- This equation is used to determine the electric energy in a system which includes an electric substance when permittivity of the dielectric substance and the strength of the electric field are known.

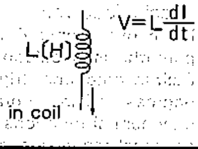
Example

Determine the electric energy density for mica with permittivity of $\varepsilon=6.2\times10^{-11}$ F/m within an electric field of E=200 V/m.

	Operation	Display
(Recall energy density stored in electrostatic field.)	SHIFT AC 26 FMLA	FMLA D ε? 0.
(Enter value for ε.)	6.2 EXP 1 1 +/- RUN	FMLA D E? 0.
(Enter value for E.)	200 RUN	FMLA D W= 1.24^{-06}

27 Magnetic Energy of Inductance

$$W=\frac{1}{2}LI^2 \qquad (L>0)$$



L is self-inductance of coil, I is current flowing in coil

- This equation is used to determine the electromagnetic energy stored in a coil when the self-inductance of the coil and current are known.

Example

Determine the electromagnetic energy stored in a coil when a current of I=6A flows to a coil with a self-inductance of L=0.07H.

	Operation	Display
(Recall magnetic energy of inductance.)	SHIFT AC 27 FMLA	FMLA D L? 0.
(Enter value for L.)	0.07 RUN	FMLA D I? 0.
(Enter value for I.)	6 RUN	FMLA D W= 1.26

14/SPECIFICATIONS

■ Basic features

- **Basic operations:** 4 basic calculations, constants for $+/-/\times/\div/x^y/x^{1/y}$, and parenthesis calculations.
- **Built-in functions:** trigonometric/inverse trigonometric functions (with angle in degrees, radians or grads), hyperbolic/inverse hyperbolic functions, logarithmic/exponential functions, reciprocals, square roots, powers, roots, decimal ↔ sexagesimal conversion, conversion of co-ordinate system (R→P, P→R), random number, π, percentages, and binary/octal/decimal/hexadecimal calculations.
- **Statistical functions:** population standard deviation, sample standard deviation, arithmetic mean, sum of square value, sum of value and number of data.
- **Impedance calculation function:** composite impedance for AC circuits (parallel/serial/mixed) that include registors, coils, and condensers. Absolute value and deviation angle of composite impedance.
- **Number of built-in formulas:** 27
- **Memory:** 1 independent memory and 6 constant memories.
- **Capacity:**

	Input range	Output accuracy
Entry/basic calculations:	10-digit mantissa, or 10-digit mantissa plus 2-digit exponent up to $10^{\pm 99}$.	
Scientific functions:		
$\sin x/\cos x/\tan x$	$\lvert x\rvert<9\times 10^9$ degrees ($5\times 10^7\pi$, 1×10^{10} grad)	±1 in the 10th digit
$\sin^{-1}x/\cos^{-1}x$	$\lvert x\rvert \leq 1$	– " –
$\tan^{-1}x$	$\lvert x\rvert<1\times 10^{100}$	– " –
$\sinh x/\cosh x$	$\lvert x\rvert\leq 230.2585092$	– " –
$\tanh x$	$\lvert x\rvert<1\times 10^{100}$	– " –
$\sinh^{-1}x$	$\lvert x\rvert<5\times 10^{99}$	– " –
$\cosh^{-1}x$	$1\leq x<5\times 10^{99}$	– " –
$\tanh^{-1}x$	$\lvert x\rvert<1$	– " –
$\log x/\ln x$	$1\times 10^{-99}\leq x\leq 10^{100}$	– " –
e^x	$-10^{100}<x\leq 230.2585092$	– " –
10^x	$-10^{100}<x<100$	– " –
x^y	$x>0\rightarrow -1\times 10^{100}<y\cdot\log x<100$	– " –
	$x=0\rightarrow y>0$	– " –
	$x<0\rightarrow y$: integer or $\pm 1/2n+1$ (n: integer)	– " –
$x^{1/y}$ ($\sqrt[y]{x}$)	$x>0\rightarrow -10^{100}<1/y\cdot\log x<100$	– " –
	$x=0\rightarrow y>0$	– " –
	$x<0\rightarrow y$: odd number or $\pm 1/n$ (n: natural number)	– " –
$\sqrt{x}$	$0\leq x<1\times 10^{100}$	– " –
$\sqrt[3]{x}$	$\lvert x\rvert<1\times 10^{100}$	– " –
x^2	$\lvert x\rvert<1\times 10^{50}$	– " –

$1/x$	$\lvert x\rvert<1\times 10^{100}$, $x\neq 0$	– " –
POL→REC	$\lvert\theta\rvert<9\times 10^9$ degrees ($5\times 10^7\pi$, 1×10^{10} grad), $0\leq r<10^{100}$	– " –
REC→POL	$\sqrt{x^2+y^2}<1\times 10^{100}$	
° ' "	up to second	
π	10 digits	

Binary	Positive :	$0\leq x\leq 111111111$
	Negative:	$1000000000\leq x\leq 1111111111$
Octal	Positive :	$0\leq x\leq 3777777777$
	Negative:	$4000000000\leq x\leq 7777777777$
Decimal	Positive :	$0\leq x\leq 2147483647$
	Negative:	$-2147483648\leq x<0$
Hexadecimal	Positive :	$0\leq x\leq$ 7FFFFFFF
	Negative:	$80000000\leq x\leq$ FFFFFFFF

*Errors are cumulative with such internal continuous calculations as x^y, $x^{1/y}$, $\sqrt[3]{\ }$, so accuracy may be adversely affected.

*In $\tan x$, $\lvert x\rvert\neq 90°\times(2n+1)$, $\lvert x\rvert\neq\pi/2\text{rad}\times(2n+1)$, $\lvert x\rvert\neq 100\text{gra}\times(2n+1)$ (n is an integer.)

*With $\sinh x$ and $\tanh x$, errors are cumulative and adversely affected when $x=0$.

■ Programmable features:

- **Total number of steps:** up to 30 (1 step performs a function).
- **Jump:** Unconditional jump (RTN), conditional jump ($x>0$, $x\leq M$).
- **Number of programs storable:** 1

■ **Decimal point:** Full floating with underflow.

■ **Read-out:** Liquid crystal display

■ **Power source:** Amorphous silicon solar cell, Lithium battery (GR927)

■ **Lithium battery life:** 7 years with GR927 (1-hour daily use).

■ **Ambient temperature range:** 0°C–40°C (32°F–104°F)

■ **Dimensions:** 8.5mmH × 73mmW × 140mmD ($^5/_{16}$"H × $2^7/_8$"W × $5^1/_2$"D)

■ **Weight:** 68 g (2.4 oz)