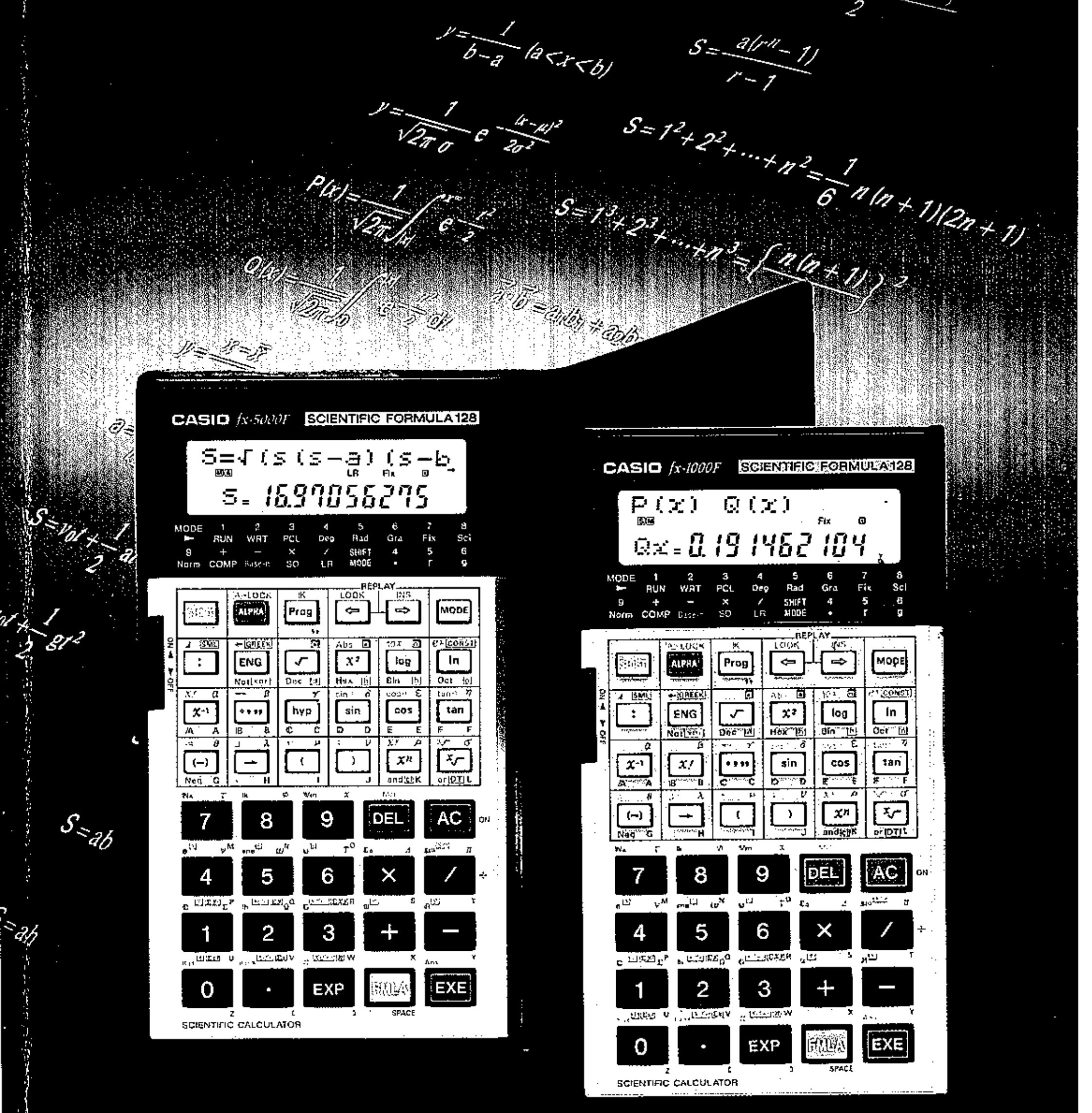
SCIENTIFIC FORMULA 128

fx-1000F/fx-5000F

OWNER'S MANUAL



CASIO®

fx-1000F/fx-5000F

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- Note that the manufacturer assumes no responsibility for any loss or claims by third parties which may arise through use of this unit.
- Note that the manufacturer assumes no responsibility for any damages incurred as a result of data loss caused by malfunctions, repairs or battery replacements. Physical records of important user formulas and data should be prepared to protect against such data losses.

Foreword

Congratulations on you selection of a CASIO calculator. The latest in modern electronics and digital technology makes almost every calculating job quicker and easier.

- Instantly reference the proper calculation from among 128 built-in formulas
- Create your own formulas or edit a built-in formula for storage in one of 12 user formula memories
- Instant access to a selection of 13 scientific constants
- A collection of handy scientific functions

The formulas, constants and scientific functions preprogrammed into the memory of your CASIO calculator keep a powerful collection of calculating tools at your fingertips.

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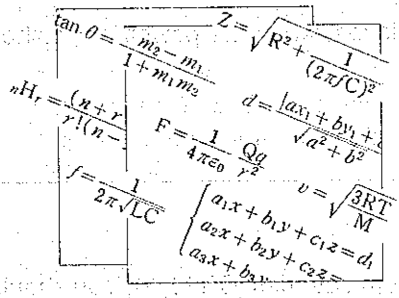
HANDLING PRECAUTIONS

- This unit is composed of precision electronic components, and should never be disassembled. Do not drop it or otherwise subject it to sudden impacts, or sudden temperature changes. Be especially careful to avoid storing the unit or leaving it in areas exposed to high temperature, humidity or large amounts of dust. When exposed to low temperatures, the unit will require more time to display answers and may even fail to operate. The display will return to normal once normal temperature is attained.
- Batteries should be replaced every 2 years even if the unit is not used for extended periods. Never leave dead batteries in the battery compartment. They can leak and cause damage to the unit.
- Strong static electricity can cause the display to weaken or lock up of the unit's functions. Should this occur, remove the batteries, replace them, and then attempt operation again.
- Avoid using volatile liquids such as thinner or benzine to clean the unit. Wipe the unit with a soft, dry cloth or a cloth that has been dipped in a neutral detergent solution and wrung out.
- If malfunction of the unit should occur, either bring or send the unit to your retailer or the nearest CASIO dealer.
  Be sure to clearly explain the problem in detail.
- Before assuming malfunction of the unit, be sure to carefully reread this manual and ensure that the problem is not due to insufficient battery power, programming or operational errors.

Chapter 1

Getting Ready



This section describes everything you need to know to set up your Casio calculator for operation. It includes such important information as how you change batteries and adjust the contrast of the display.

1-1 Switching Power ON and OFF

The power switch is located on the left edge of the calculator. You switch power ON by sliding the switch up, and OFF by sliding the switch down.

Even if you leave the calculator ON, an Auto Power OFF function saves valuable battery power. This function automatically switches power OFF if you don't use the calculator for about six minutes. To switch power back on after operation of the Auto Power OFF function, simply press the AC key.

Note that nothing in the calculator's memory is lost when the power is switched OFF.

1-2 Loading Batteries

Power is supplied to your calculator by two lithium batteries (CR2032). You should replace the batteries in the calculator when the characters on the display become too dim to read, even if you make the contrast darker (see 1-3 Adjusting the Contrast). Remember to always replace both batteries.

IMPORTANT

- To protect your calculator against damage from leaking batteries, replace batteries once every two years no matter how much you use it.
- Remember that removing the batteries cuts off the power to the calculator so any formulas (except the preprogrammed formulas) or data you have in memory may be lost. If you load the new batteries quickly enough, it is possible that you will be able to change batteries without losing any information. In any case, you should always check the contents of the memory and write down any important stored information before you remove the batteries from the calculator.
- If the battery power should be allowed to decrease or if batteries are removed from the unit for extended periods, user generated formulas and memory contents may be erased or altered. In this case, the RESET button located on the back of the unit should be pressed using pointed object. All memory contents and user generated formulas will be erased.
- Always keep batteries out of the reach of small children. Contact a doctor immediately if a battery is accidentally swallowed.
- Never dispose of old batteries in such a way that they will be incinerated. Batteries may explode if exposed to fire.

■ Procedure

① Switch the power of the calculator OFF.

② Loosen the two screws on the back of the calculator and remove the back cover.

③ Remove the screw fastening the battery holder in place and remove the holder.

④ Remove the two batteries (if present) from the calculator.
**You can remove the batteries by turning the calculator with its back downwards and tapping the corner of the calculator lightly on a desk or table.*

⑤ Wipe two new batteries with a soft cloth and load them into the calculator with their positive poles (indicated by the ⊕ mark) facing upwards.

⑥ Replace the battery holder and fasten it in place using its original screw.

⑦ Replace the back cover of the calculator and its two screws.

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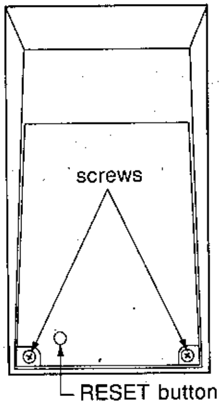

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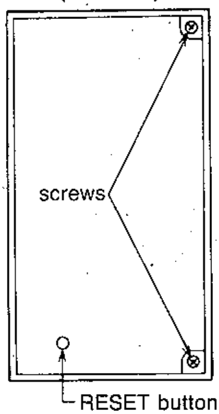

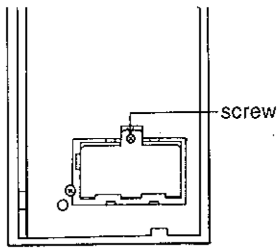

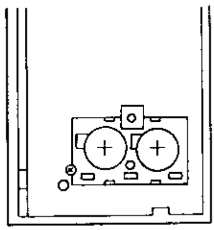

1-3 Adjusting the Contrast

The characters that are shown on the display of the calculator may sometimes appear dim because of your viewing angle or because the batteries powering the calculator have become weak. You can adjust the contrast of the display using a dial located on the right edge of the calculator.

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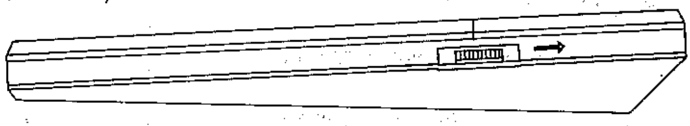

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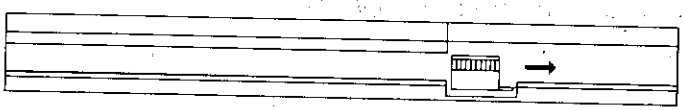
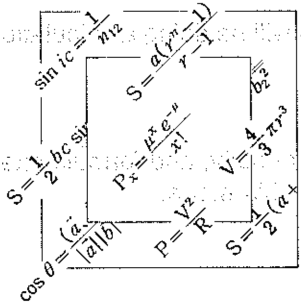


If you turn the dial in the direction shown by the arrow in the illustration, the characters on the display become darker. Turning the dial in the opposite direction makes the characters lighter. If the display is difficult to read even after you make the contrast as dark as possible, it might mean that you need to replace the batteries.

Chapter 2
Getting to Know Your Calculator



This Chapter gives you some basic information that is applicable to the general use of your calculator. It describes the use of calculation modes, and provides important information on how you can change, delete, and insert characters on the display. You can find detailed descriptions of the keys and other controls in the general guide in Appendix A in the back of this manual.

2-1 Using the Calculation Modes

Your calculator can perform a large number of sophisticated calculations. In order to make operation as easy as possible, the calculator is programmed so that calculations are assigned to specific modes. You can select the mode you need using the [MODE] key in the combinations noted below. Be sure that the calculator is set to the correct mode before you begin your calculation.

■ Operation Modes

The operation mode you select determines if you will be doing a calculation, storing or editing a formula, or deleting a formula.

•RUN mode [MODE] [1]
Normal calculations where values are entered manually, and formula execution. Scientific calculations can also be performed in this mode.

•WRT mode [MODE] [2]
Formula storage and editing.
The symbol WRT appears on the display when you select this mode.

•PCL mode [MODE] [3]
Deletion of stored formulas.
The symbol PCL appears on the display when you select this mode.

■ Calculation Modes

You should also select the proper calculation mode in accordance with the type of operation you will perform.

•COMP mode [MODE] [+]
General calculations where values are entered manually, including calculations which contain scientific functions.

•Base-*n* mode [MODE] [−]
Binary, octal, decimal, hexadecimal conversions/calculations, logical operations. One of the following symbols appears at the right of the display to indicate the currently selected number system when you select this mode.

b: binary, o: octal, d: decimal, h: hexadecimal

This mode cannot be selected for calculations which contain scientific functions or when using the formula function.

•SD mode MODE ×

Standard deviation calculations (single-variable statistics).
The symbol SD appears on the display when you select this mode.

•LR mode MODE ÷

Regression calculations (paired-variable statistics).
The symbol LR appears on the display when you select this mode.

2-2 Correcting Entries on the Display

After you have input a calculation formula, you can make any changes you need without having to restart input from the beginning.

■ Changing a Character or Function

You can make changes in a display at any time by moving to the character or function to be changed and then pressing the key for the correct entry.

① Use the cursor keys to move the cursor to the location of the correction.
**The cursor is the small flashing line on the display that indicates the current input position. The ⇦ and ⇨ cursor keys are used to move the cursor to the left and right.*

② Press the key for the correct character or function.

③ Press EXE to perform the calculation or use the cursor keys to move the cursor to another position.

Example 1

Change 122 to 123.

Key operation	Display
1 2 2	1 2 2 _
⇦	1 2 2
3	1 2 3 _

Example 2

Change cos60 to sin60.

Key operation	Display
cos 6 0	cos 60_
⇦ ⇦ ⇦	cos 60
sin	sin 60

■ Deleting a Character or Function

You can delete characters or functions from a display by moving the cursor to the delete position and then pressing the DEL key.

① Use the cursor keys to move the cursor to the location of the deletion.

② Press the DEL key to delete the character or function.

③ Press EXE to perform the calculation or use the cursor keys to move the cursor to another position.

Example

Change 369× ×2 to 369×2.

3 6 9 × × 2	369××2_
⇦ ⇦ DEL	369×2

■ Inserting a Character or Function

You can insert characters or functions between other characters or functions on the display by moving the cursor to the insert position and then pressing SHIFT INS to enter the insert mode for the insertion.

① Use the cursor keys to move the cursor to the location of the insertion.

② Press SHIFT INS to enter the insert mode.

**When you press SHIFT INS, the space that is opened is displayed as " [ ] ". Though the [ ] will remain within the calculation even if nothing is inserted, it is disregarded during calculations. Calculations will execute normally when you press the EXE key even when [ ] is contained within the calculation. You can exit the insert mode by pressing ⇦, ⇨, SHIFT INS, or EXE.*

③ Press the keys for the characters or functions you wish to insert.

④ Press EXE to perform the calculation or use the cursor keys to move the cursor to another position.

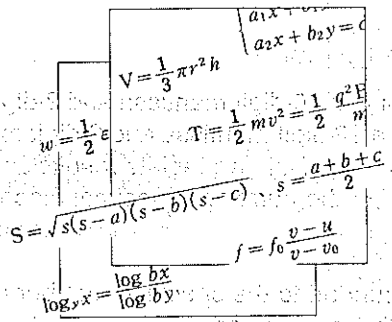
Example

Change 2.36^2 to $\sin 2.36^2$.

[2] [•] [3] [6] [x^2]	2.36^2_
[⇦] [⇦] [⇦] [⇦] [⇦]	2.36^2
[SHIFT] [INS]	2.36^2
[sin]	$\sin 2.36^2$

Chapter 3

Manual Calculations



In this manual, the term *manual calculations* is used to mean calculations that you enter by hand, using the keys. These calculations are different from *formula calculations* and *formula memory calculations* which are explained in another part of this manual.

This Chapter describes the *manual calculations* which you can perform, as well as certain functions which make handling such calculations quicker and easier.

The calculations shown in the examples in this section assume that you have a certain level of familiarity with mathematical principles and terms. Many of the operations described in this section are illustrated by simply showing examples, without including detailed explanations of fundamental mathematical operations.

3-1 Specifying the Format of Calculation Results

You can change the precision of calculation results by specifying the number of decimal places or the number of significant digits. You can also shift the decimal place of a displayed value three places to the left or right for one-touch conversions of metric weights and measures.

*You cannot specify the display format (FIX, SCI) while the calculator is in the Base-*n* mode. Such specifications can only be made if you first exit the Base-*n* mode.

■ Specifying the Number of Decimal Places

The calculator always performs calculations using a 10-digit mantissa and 2-digit exponent, and results are stored in memory as a 12-digit mantissa and 2-digit exponent no matter how many decimal places you specify. Intermediate results and final results are then automatically rounded off to the number of decimal places you have specified.

It should be noted that *displayed* results are rounded to the specified number of decimal places, but *stored* results are normally not rounded.

① Perform a calculation or enter a value.

② Press the [EXE] key.

③ Press [MODE] [7].

④ Press a number key from [0] through [9] to specify the number of decimal places.
**At this time you should be able to see "Fix" on the display.*
You count the number of decimal places from left to right, starting to the right of the decimal point. This means that the value 1.234 has three decimal places.

⑤ Press [MODE] [9] [EXE].
**This cancels any specification and returns the number of decimal places to the original value.*

If you do not perform step ⑤, the number of decimal places you specified in step ④ will remain in effect, even if you switch the power of the calculator OFF.

Example	Operation	Display
100÷6=16.66666666···	100 [÷] 6 [EXE]	16.66666667
	[MODE] [7] [4] [EXE] (4 decimal places)	16.6667
	[MODE] [9] [EXE] (Cancel specification)	16.66666667
200÷7×14=400 (rounded to 3 decimal places, without rounding of the stored intermediate result)	**200 [÷] 7 [×] 14** [EXE]	400.
	[MODE] [7] [3] [EXE] (3 decimal places)	400.000
	200 [÷] 7 [EXE] (The intermediate result is automatically rounded to the specified three decimal places.)	28.571
The stored 10-digit result (28.57142857) is used when you continue the calculation by simply pressing [×] or any other arithmetic/function key.	[×]	28.57142857×_
	14 [EXE] (The final result is automatically rounded to the specified three decimal places.)	400.000
	[MODE] [9] [EXE] (Cancels specification.)	400.

■ Rounding the Intermediate Result

Compare the final result you obtained in the previous example with the final result of the following example.

Example	Operation	Display
200÷7×14=400	200 [÷] 7 [×] 14 [EXE]	400.
(rounded to 3 decimal places, with rounding of the stored intermediate result)	[MODE] [7] [3] [EXE] (3 decimal places)	400. 000
	200 [÷] 7 [EXE] (The intermediate result is automatically rounded to the specified three decimal places.)	28. 571
	[SHIFT] [Rnd] [EXE] (This rounds the stored intermediate result to the specified three decimal places.)	28. 571
	[×]	28. 571×_
	14 [EXE]	399. 994
	[MODE] [9] [EXE] (Cancels specification.)	399. 994

■ Specifying the Number of Significant Digits

This specification is used to automatically round intermediate results and final results to the number of digits you have specified.

As with the number of decimal places, *displayed* results are rounded to the specified number of digits, but *stored* results are normally not rounded.

① Perform a calculation or enter a value.

② Press the [EXE] key.

③ Press [MODE] [8].

④ Press a number key from [1] through [0] (representing 1 through 10) to specify the number of significant digits.
**At this time you should be able to see "Sci" on the display.*
The value 1.234 has four significant digits.

⑤ Press MODE 9 EXE.

This cancels any specification and returns the number of significant digits to the original value.

If you do not perform step ⑤, the number of significant digits you specified in step ④ will remain in effect, even if you switch the power of the calculator OFF.

Example	Operation	Display
100÷6=16.66666666···	100 ÷ 6 EXE	16.66666667
	MODE 8 5 EXE (5 significant digits)	1.6667[01]
	MODE 9 EXE (Cancel specification.)	16.66666667

■ Shifting the Decimal Place

You can use the ENG key to shift the decimal point of the displayed value three places to the left or right. Each 3-place shift to the left is the same as dividing the value by 1000, and each shift to the right is the same as multiplying by 1000. This means that this function is useful when converting metric weights and measures to other metric units.

Example	Operation	Display
123m×456=56088m	123 × 456 EXE	56088.
=56.088km	ENG	56.088[03]
78g×0.96=74.88g	78 × 0.96 EXE	74.88
=0.07488kg	SHIFT ENG (←)	0.07488[03]

3-2 Basic Calculations

Basic calculations are those which include such arithmetic operations as addition, subtraction, multiplication, and division, as well as terms contained within parentheses. To input basic calculations press keys for numbers, operators, and parentheses in left-to-right sequence, just as the calculation would be written on paper.

■ Performing Arithmetic Calculations

① Enter the calculation.

**Press the proper keys in the left-to-right sequence of the calculation as it is written. Use the [−] key for subtraction, and the [(−)] key in front of negative numbers.*

**For mixed calculations, multiplication and division are given priority over addition and subtraction (so $3+5\times6$ is performed as $5\times6\rightarrow30+3\rightarrow33$). Appendix C contains information on the order of other operations.*

② Press the [EXE] key to obtain the result of the calculation.

- Results of 10-billion or greater or less than 0.01 are displayed in exponential format.
- Internal calculations are performed with a 12-digit mantissa, with the displayed result rounded off to 10 digits.

Example	Operation	Display
$23+4.5-53=-25.5$	23 [+] 4.5 [−] 53 [EXE]	-25.5
$56\times(-12)\div(-2.5)=268.8$	56 [×] [(−)] 12 [÷] [(−)] 2.5 [EXE]	268.8
$12369\times7532\times74103=$ 6.903680613×10^{12} (6903680613000)	12369 [×] 7532 [×] 74103 [EXE]	6.903680613^{12} Exponential display
$(4.5\times10^{75})\times(-2.3\times10^{-79})=$ -1.035×10^{-3} (-0.001035)	4.5 [EXP] 75 [×] [(−)] 2.3 [EXP] [(−)] 79 [EXE]	1.035^{-03}
$(1\times10^{5})\div7=14285.71429$	1 [EXP] 5 [÷] 7 [EXE]	14285.71429
$(1\times10^{5})\div7-14285=0.7142857$	1 [EXP] 5 [÷] 7 [−] 14285 [EXE]	0.7142857
$3+\underline{5\times6}=33$	3 [+] 5 [×] 6 [EXE]	33.
$7\times8-\underline{4\times5}=36$	7 [×] 8 [−] 4 [×] 5 [EXE]	36.
$1+2-\underline{3\times4\div5}+6=6.6$	1 [+] 2 [−] 3 [×] 4 [÷] 5 [+] 6 [EXE]	6.6

■ Using Parentheses in Calculations

Insert open parentheses by pressing the [(] key, and closed parentheses by pressing the [)] key.

Example	Operation	Display
$100-(2+3)\times 4=80$	100 [−] [(] 2 [+] 3 [)] [×] 4 [EXE]	80.
$2+3\times(4+5)=29$	2 [+] 3 [×] [(] 4 [+] 5 [EXE]	29.
*You may omit closed parentheses which come immediately before the [EXE] key (no matter how many are required).		
$(7-2)\times(8+5)=65$	[(] 7 [−] 2 [)] [(] 8 [+] 5 [EXE]	65.
*You may also omit [×] for the multiplication operation immediately before an open parentheses.		
$10-\{2+7\times(3+6)\}=-55$	10 [−] [(] 2 [+] 7 [(] 3 [+] 6 [EXE]	-55.
*For the sake of clarity, all closed parentheses and [×] key operations are shown in this manual, whether they are required or not.		
$\frac{2\times3+4}{5}=(2\times3+4)\div5=2$	[(] 2 [×] 3 [+] 4 [)] [÷] 5 [EXE]	2.
$\frac{5\times6+6\times8}{15\times4+12\times3}=0.8125$	[(] 5 [×] 6 [+] 6 [×] 8 [)] [÷] [(] 15 [×] 4 [+] 12 [×] 3 [)] [EXE]	0. 8125
$(1.2\times10^{19})-\{(2.5\times10^{20})\times\frac{3}{100}\}=4.5\times10^{18}$	1.2 [EXP] 19 [−] [(] 2.5 [EXP] 20 [×] 3 [÷] 100 [)] [EXE]	4.5^{18}
$\frac{6}{4\times5}=0.3$	6 [÷] [(] 4 [×] 5 [)] [EXE]	0. 3
*The above is the same as 6 [÷] 4 [÷] 5 [EXE].		

3-3 Making Calculations Quicker and Easier

■ Using Results in Other Calculations

Once you obtain the result for a calculation by pressing the [EXE] key you can use that result in further calculations if it is still displayed.

Example 1

3×4=12, continuing with ∕3.14

Key operation	Display
3 [×] 4 [EXE]	12.
(followed by) [∕] 3.14	12.∕3.14_
[EXE]	3.821656051

Example 2

Compare: 1∕3×3
1∕3, followed by ×3

Key operation	Display
1 [∕] 3 [×] 3 [EXE]	1.
1 [∕] 3 [EXE]	0.333333333
(followed by) [×] 3 [EXE]	0.999999999

■ Recalling Results from the Answer Memory

The answer memory automatically stores the result of the last calculation that you have performed. Notice that the result is stored automatically, which makes it different from the constant memories described later. The contents of the answer memory are updated whenever you press the [EXE] key after you input a value or calculation. You can check the contents of the answer memory using the following procedure.

•Recalling Results from the Answer Memory

① Press [SHIFT] followed by the [Ans] key.

**This causes "Ans" to appear on the display to represent the contents of the answer memory.*

② Press the [EXE] key.

**This step is necessary to change "Ans" to the actual value stored in the answer memory.*

•Using the Answer Memory in a Calculation

You can recall "Ans" at any time, and even use it within a formula or calculation. Remember, when you press the [EXE] key at the end of the calculation, the answer memory contents change to the result of the calculation you have just performed.

Example

Perform the calculation 123 + 456 = 579, followed by 789 − 579 (which is the result of the previous calculation).

[1] [2] [3] [+] [4] [5] [6] [EXE]	579.
[7] [8] [9] [−] [SHIFT] [Ans]	789 - Ans_
[EXE]	210.

As with the constant memories, you do not need to press the [×] key when the answer memory is used in a multiplication operation.

Example

Operation	Input
2 × Ans	[2] [SHIFT] [Ans]
Ans × (5 + 3)	[SHIFT] [Ans] [(] [5] [+] [3] [)]

Note that the contents of the answer memory are not changed when you use the [EXE] key to store a value in a constant memory (see the following section for details on constant memories).

Example

[7] [8] [+] [5] [6] [EXE] (Result stored in answer memory.)	134.
[SHIFT] [Ans] [EXE] (Check answer memory contents.)	134.
[1] [2] [3] [→] [SHIFT] [K] [0] [EXE] (Value stored in constant memory.)	123.
[SHIFT] [Ans] [EXE] (Check answer memory contents.)	134.

■ Using Constant Memories

Your calculator is equipped with ten independent constant memories which let you individually store values and use them in calculations. You specify these memories by pressing the [IK] key followed by any number key from [0] through [9].

•Storing a Value to a Constant Memory

① Enter the value to be stored.

② Press the [→] key.

③ Specify a constant memory number.

④ Press [EXE].

Example

Store 123 in constant memory IK0.

[1][2][3][→][SHIFT][IK][0] → `123→IK0_`

[EXE] → `123.`

•Storing a Calculation Result to a Constant Memory

① Perform the calculation.

② Press the [→] key.

③ Specify a constant memory number.

④ Press [EXE].

Example

Store the result of 2+2 in constant memory IK5.

[2][+][2][→][SHIFT][IK][5] → `2+2→IK5_`

[EXE] → `4.`

•Recalling from a Constant Memory

① Specify a constant memory number.

② Press EXE.
**This step is necessary to change the displayed constant memory number to the actual value stored in the constant memory.*

Example

Recall the value stored in constant memory IK0.

Key operation	Display
SHIFT IK 0	IK 0 _
EXE	123.

•Using Constant Memories in Calculations

You can use values stored in constant memories by simply specifying the memory number where the value would normally appear in a calculation. You can store the final result of a calculation in a constant memory by specifying the constant memory where the equal sign would normally appear in the calculation.

Example 1

Subtract 30 from the value stored in constant memory IK0 (123) and store the result in constant memory IK1.

Key operation	Display
SHIFT IK 0 − 3 0 → SHIFT IK 1	IK 0 − 3 0→IK 1 _
EXE	93.

Example 2

Subtract the value stored in IK1 (93) from the value stored in IK0 (123).

Key operation	Display
SHIFT IK 0 − SHIFT IK 1	IK 0 − IK 1 _
EXE	30.

Example 3

Add 23 to the value stored in constant memory IK0 (123) and store the result in constant memory IK0.

Key operation	Display
SHIFT IK 0 + 2 3 → SHIFT IK 0	IK 0 + 2 3→IK 0 _
EXE	146.

Note that you do not need to press the [×] key when a variable memory is used in a multiplication operation.

Example

Operation	Input
2×IK0	[2] [SHIFT] [IK] [0]
IK1×(IK0+IK2)	[SHIFT] [IK] [1] [(] [SHIFT] [IK] [0] [+] [SHIFT] [IK] [2] [)]

•Clearing a Specific Constant Memory

① Press the [0] key.

② Press the [→] key.

③ Specify the number of the constant memory to be cleared.

④ Press the [EXE] key.

Example

Clear constant memory IK0.

[0] [→] [SHIFT] [IK] [0] [EXE] | 0.

•Clearing All Constant Memories

① Press the [SHIFT] key.

② Press the [Mcl] key.

③ Press the [EXE] key.

Example

Clear all constant memories.

[SHIFT] [Mcl] | Mcl_

[EXE] | 0.

Note that constant memories are not cleared when you press the [AC] key or switch the power of the calculator OFF.

■ Recalling Calculation Sequences

After you obtain the result of a calculation by pressing the [EXE] key you notice a mistake. Or maybe you have to do a long series of calculations which are only slightly different from each other. With your Casio calculator, you don't need to input the entire calculation sequence from beginning to end. Just do the following.

① Press either the [⇦] or [⇨] key.

**Which key you should press depends on where in the sequence the mistake is located.*

**The [⇨] key shows the sequence with the cursor located on the left of the display, under the first character in the sequence.*

**The [⇦] key shows the sequence with the cursor located on the right of the display, following the last character in the sequence.*

② Use the [⇦] and [⇨] keys to move the cursor to the location of the mistake.

③ Make the required corrections.

**Corrections are made using the delete and insert procedures described in 2-2 Correcting Entries on the Display.*

④ Move the cursor to another location, or press the [EXE] key to execute the new sequence.

Example

Change $4.12 \times 3.58 \underline{+6.4} = 21.1496$ to $4.12 \times 3.58 \underline{-7.1} = 7.6496$

4.12 [×] 3.58 [+] 6.4 [EXE]	21.1496
[⇦]	4.12×3.58+6.4_
[⇦][⇦][⇦][⇦]	4.12×3.58+6.4
[−] 7.1	4.12×3.58−7.1_
[EXE]	7.6496

It should be noted that calculation sequences cleared when the [AC] key is pressed, the power of the calculator is switched OFF, or the mode is changed.

■ Correcting Errors Indicated by Error Messages

Certain errors are pointed out by the appearance of the error messages described in Appendix B when the [EXE] key is pressed. Your Casio calculator lets you recall the calculation sequence and instantly locate the error.

When an error is displayed:

① Press either the [⇐] or [⇒] key (it doesn't matter which).
The calculation sequence appears on the display with the cursor positioned automatically at the location of the error.

② Make the required corrections.
Corrections are made using the delete and insert procedures described in 2-2 Correcting Entries on the Display.

③ Press the [EXE] key to execute the new sequence.

Example

Input of 14/0×2.3 causes an error to appear (because division by zero is impossible). Change the sequence to 14/10×2.3.

Key operation	Display
14 [/] 0 [×] 2.3 [EXE]	Ma ERROR
[⇒] (or [⇐])	14/0×2.3
	Error occurs here.
[⇐] [SHIFT] [INS] 1	14/10×2.3
[EXE]	3.22

■ Chaining a Series of Calculations

Your Casio calculator lets you chain multiple calculations into a series that is treated as a single calculation sequence. You can use one of three different symbols to connect each calculation in the chain. Chained calculations are performed one-by-one, in the same left-to-right sequence as they would appear when written down.

" : " — This connector tells the calculator to pause until the [EXE] key is pressed, and retains the values which have been assigned to variables.

" ◢ " —This connector tells the calculator to pause until the [EXE] key is pressed, and clears the values which have been assigned to variables.

" ˩ " —This connector tells the calculator to clear the values which have been assigned to variables, without displaying any intermediate results.

Note that each portion of a chained series is actually an individual calculation. This means that you couldn't use a sequence such as the following:

123 [×] 456 [:] [+] 5

Example

Chain 6.9×123 and 123/3.2

The above sequence can also be input as:

123 [→] [SHIFT] [IK] 0 [:] 6 . 9 [×] [SHIFT] [IK] 0 [SHIFT] [◢] [SHIFT] [IK] 0 [÷] 3 . 2 [EXE]	123
[EXE]	848.7
[EXE]	38.4375

3-4 Using Scientific Functions in Calculations

■ Specifying the Unit of Angular Measurement

You will often find it necessary to work with various units of angular measurement when performing calculations that include scientific functions. The following shows the unit and the indicator which appears on the display for each specification of a unit of angular measurement.

Input	Unit	Display
MODE 4 EXE	Degrees	D
MODE 5 EXE	Radians	R
MODE 6 EXE	Grads	G

The unit of angular measurement you specify remains in effect until you change it, even if you switch the power of the calculator OFF.

*You cannot specify the unit of angular measurement (degrees, radians, grads) while the calculator is in the Base-*n* mode. Such specifications can only be made if you first exit the Base-*n* mode.

■ Specifying the Unit of Angular Measurement for a Specific Value

No matter what unit of angular measurement is now specified, you can still input a value from another unit of angular measurement. The following shows which keys you should press for each unit of angular measurement immediately after you input the value.

Input	Unit
SHIFT MODE 4	Degrees
SHIFT MODE 5	Radians
SHIFT MODE 6	Grads

Example	Operation	Display
4.25 radians to degrees	MODE 4 EXE → "D"	
	4.25 SHIFT MODE 5 EXE	243.5070629
1.23 grads to radians	MODE 5 EXE → "R"	
	1.23 SHIFT MODE 6 EXE	0.019320794
7.89 degrees to grads	MODE 6 EXE → "G"	
	7.89 SHIFT MODE 4 EXE	8.766666667
Result in degrees	MODE 4 EXE → "D"	
47.3°+82.5rad=4774.20181	47.3 + 82.5 SHIFT MODE 5 EXE	4774.20181
12.4°+8.3rad−1.8gra=	12.4 + 8.3 SHIFT MODE 5 −	
486.33497	1.8 SHIFT MODE 6 EXE	486.33497

Example	Operation	Display
Result in radians		
24°6'31"+85.34rad= 85.76077464	[MODE] [5] [EXE] → "R" 24 [°'"] 6 [°'"] 31 [°'"] [SHIFT] [MODE] [4] [+] 85.34 [EXE]	85.76077464
Result in grads	[MODE] [6] [EXE] → "G"	
36.9°+41.2rad=2663.873462	36.9 [SHIFT] [MODE] [4] [+] 41.2 [SHIFT] [MODE] [5] [EXE]	2663.873462

■ Using Trigonometric and Inverse Trigonometric Functions

You can include trigonometric and inverse trigonometric functions in calculations. You should also check that the unit of angular measurement is set to the unit you want the final result to be.

Example	Operation	Display
sin63°52'41"=0.897859012	[MODE] [4] [EXE] → "D" [sin] 63 [°'"] 52 [°'"] 41 [°'"] [EXE]	0.897859012
$\cos\left(\frac{\pi}{3}\text{rad}\right)=0.5$	[MODE] [5] [EXE] → "R" [cos] [(] [SHIFT] [π] [÷] 3 [)] [EXE]	0.5
tan(−35gra)=−0.612800788	[MODE] [6] [EXE] → "G" [tan] [(−)] 35 [EXE]	−0.612800788
2·sin45°×cos65°=0.597672477	[MODE] [4] [EXE] → "D" 2 [×] [sin] 45 [×] [cos] 65 [EXE] Can be omitted.	0.597672477
$\sin^{-1}0.5=30°$ (Find the value of x when $\sin x=0.5$)	[SHIFT] [sin⁻¹] 0.5 [EXE] Can be entered as .5.	30.
$\cos^{-1}\frac{\sqrt{2}}{2}=0.785398163\text{rad}$ $=\frac{\pi}{4}\text{rad}$	[MODE] [5] [EXE] → "R" [SHIFT] [cos⁻¹] [(] [√] 2 [÷] 2 [)] [EXE] [÷] [SHIFT] [π] [EXE]	0.785398163 0.249999999
$\tan^{-1}0.741=36.53844577°$ $=36°32'18.4"$	[MODE] [4] [EXE] → "D" [SHIFT] [tan⁻¹] 0.741 [EXE] [SHIFT] [←°'"]	36.53844577 36°32°18.4

*If the result of a calculations that uses degrees as the unit of angular measurement is longer than eight digits, the result is displayed from the left, with the right side digits being cut off. This is only for the display, and the entire result is stored internally as a decimal value.

Example	Operation	Display
$2.5\times(\sin^{-1}0.8-\cos^{-1}0.9$ $=68°\ 13'\ 13.53''$	2.5 × (SHIFT sin 0.8 − SHIFT cos 0.9) EXE SHIFT ←°'"	68° 13° 13. 53
$\sin 18°\times\cos 0.25\text{rad}=$ 0.299410404	sin 18 × cos 0.25 SHIFT MODE 5 EXE	0. 299410404
*The above is calculated in radians, and is identical to sin 18 SHIFT MODE 4 × cos 0.25 EXE.		

■ Using Logarithmic and Exponential Functions

You can include logarithmic and exponential functions in calculations.

Example	Operation	Display
$\log 1.23(\log_{10}1.23)=8.9905111\times10^{-2}$	log 1.23 EXE	0. 089905111
$\ln 90(\log_e 90)=4.49980967$	ln 90 EXE	4. 49980967
$\log 456\div\ln 456=0.434294481$	log 456 ÷ ln 456 EXE	0. 434294481
$10^{1.23}=16.98243652$ (Anti-logarithm of common logarithm 1.23)	SHIFT 10^x 1.23 EXE	16. 98243652
$e^{4.5}=90.0171313$ (Anti-logarithm of natural logarithm 4.5)	SHIFT e^x 4.5 EXE	90. 0171313
$10^4\cdot e^{-4}+1.2\cdot10^{2.3}=422.5878667$	SHIFT 10^x 4 × SHIFT e^x (−) 4 + 1.2 × SHIFT 10^x 2.3 EXE	422. 5878667
$3^6=729$	3 x^y 6 EXE	729.
$2^{1^1}=2048$	2 x^y 1 x^y 1 EXE	2048.
$5.6^{2.3}=52.58143837$	5.6 SHIFT x^y 2.3 EXE	52. 58143837
$\sqrt[7]{123}(=123^{\frac{1}{7}})=1.988647795$	7 $\sqrt[x]{y}$ 123 EXE	1. 988647795
$(78-23)^{-12}=1.305111829\times10^{-21}$	(78 − 23) SHIFT x^y (−) 12 EXE	1. 305111829^{-21}
$2+3\times\sqrt[3]{64}-4=10$	2 + 3 × 3 $\sqrt[x]{y}$ 64 − 4 EXE	10.
$2\times3.4^{(5+6.7)}=3306232.001$	2 × 3.4 SHIFT x^y (5 + 6.7) EXE	3306232. 001

■ Hyperbolic and Inverse Hyperbolic Functions (fx-5000F)

You can include hyperbolic and inverse hyperbolic functions in calculations.

Example	Operation	Display
$\sinh 3.6 = 18.28545536$	[hyp] [sin] 3.6 [EXE]	18.28545536
$\cosh 1.23 = 1.856761057$	[hyp] [cos] 1.23 [EXE]	1.856761057
$\tanh 2.5 = 0.986614298$	[hyp] [tan] 2.5 [EXE]	0.986614298
$\cosh 1.5 - \sinh 1.5 = 0.22313016$	[hyp] [cos] 1.5 [−] [hyp] [sin] 1.5 [EXE]	0.22313016
$= e^{-1.5}$ (Proof of $\cosh x \pm \sinh x = e^{\pm x}$)	(Continuing) [ln] [SHIFT] [Ans] [EXE]	−1.5
$\sinh^{-1} 30 = 4.094622224$	[hyp] [SHIFT] [sin] 30 [EXE]	4.094622224
$\cosh^{-1}\left(\frac{20}{15}\right) = 0.795365461$	[hyp] [SHIFT] [cos] [(] 20 [÷] 15 [)] [EXE]	0.795365461
Value of x when $\tanh 4x = 0.88$ $x = \frac{\tanh^{-1} 0.88}{4} = 0.343941914$	[hyp] [SHIFT] [tan] 0.88 [÷] 4 [EXE]	0.343941914
$\sinh^{-1} 2 \times \cosh^{-1} 1.5 = 1.389388923$	[hyp] [SHIFT] [sin] 2 [×] [hyp] [SHIFT] [cos] 1.5 [EXE]	1.389388923
$\sinh^{-1}\left(\frac{2}{3}\right) + \tanh^{-1}\left(\frac{4}{5}\right) = 1.723757406$	[hyp] [SHIFT] [sin] [(] 2 [÷] 3 [)] [+] [hyp] [SHIFT] [tan] [(] 4 [÷] 5 [)] [EXE]	1.723757406

■ Using Other Scientific Functions

Example	Operation	Display
$\sqrt{2}+\sqrt{5}=3.65028154$	[√] 2 [+] [√] 5 [EXE]	3.65028154
$2^2+3^2+4^2+5^2=54$	2 [x²] [+] 3 [x²] [+] 4 [x²] [+] 5 [x²] [EXE]	54.
$\frac{1}{\frac{1}{3}-\frac{1}{4}}=12$	[(] 3 [x⁻¹] − 4 [x⁻¹] [)] [x⁻¹] [EXE]	12.
$8!(=1\times2\times3\times\cdots\cdots\times8)=$ 40320	8 [x!]* [EXE] *With the fx-5000F, press [SHIFT] [x!]	40320.
$\sqrt[3]{36\times42\times49}=42$	[SHIFT] [∛] [(] 36 [×] 42 [×] 49 [)] [EXE]	42.
Random number generation (pseudo-random number from 0.000 to 0.999)	[SHIFT] [Ran#] [EXE]	(Ex.) 0.792
$\sqrt{13^2-5^2}+\sqrt{3^2+4^2}=17$	[√] [(] 13 [x²] [−] 5 [x²] [)] [+] [√] [(] 3 [x²] [+] 4 [x²] [)] [EXE]	17.
$\sqrt{1-\sin^2 40^\circ}=0.766044443$ $=\cos 40^\circ$ (Proof of $\cos\theta=\sqrt{1-\sin^2\theta}$)	[MODE] [4] [EXE] → "D" [√] [(] 1 [−] [(] [sin] 40 [)] [x²] [)] [EXE] (Continuing) [SHIFT] [cos⁻¹] [SHIFT] [Ans] [EXE]	 0.766044443 40.
$\frac{1}{2!}+\frac{1}{4!}+\frac{1}{6!}+\frac{1}{8!}=$ 0.543080357	2 [x!]* [x⁻¹] [+] 4 [x!]* [x⁻¹] [+] 6 [x!]* [x⁻¹] [+] 8 [x!]* [x⁻¹] [EXE] *With the fx-5000F, press [SHIFT] [x!]	0.543080357
Absolute value of common logarithm of $\frac{3}{4}$. $\left\lvert\log\frac{3}{4}\right\rvert=0.124938736$	[SHIFT] [Abs] [log] [(] 3 [a b/c] 4 [)] [EXE]	0.124938736

3-5 Working with Number Systems

The Base-n mode lets you perform a variety of operations with values of different number systems. These include actual calculations, conversions from one number system to another, and logical operations. The Base-n mode is very useful because it lets you move among binary, octal, decimal and hexadecimal number systems. Due to the complexity of some conversions, however, you must observe the following precautions when using this mode.

- You cannot use scientific functions and the formula function in the Base-n mode.
- You cannot specify the unit of angular measurement (degrees, radians, grads) or the display format (FIX, SCI) while the calculator is in the Base-n mode. Such specifications can only be made if you first exit the Base-n mode.
- Only integers are valid in the Base-n mode, so the calculator ignores any operation of the [•] key, and decimal parts of calculation results are automatically cut off.
- Negative binary, octal, and hexadecimal numbers are expressed using their twos" complements.
- Alphabetic characters A through F used in hexadecimal notation are distinguished from standard alphabetic characters as follows.

Key	Display	⟨fx-1000F⟩	⟨fx-5000F⟩
[/A]	/A	[/A] = [x^{-1}]	[/A] = [x^{-1}]
[IB]	IB	[IB] = [$x!$]	[IB] = [°'"]
[C]	C	[C] = [°'"]	[C] = [hyp]
[ID]	ID	[ID] = [sin]	[ID] = [sin]
[IE]	IE	[IE] = [cos]	[IE] = [cos]
[IF]	IF	[IF] = [tan]	[IF] = [tan]

You can specify the number system for all values being used in the current operation, and you can also specify the number system for a specific value.

•Specifying the Standard Number System

The standard number system you specify remains in effect until you change it, even if you switch the power of the calculator OFF.

① Press [MODE] [−] for the Base-n mode.

② Specify the number system by pressing a number system key followed by the [EXE] key.

The following shows the number systems that you can specify, as well as the indicator which appears on the display and the maximum size of values that you can use in each number system.

Key	Number System	Display	Maximum Size
Bin EXE	Binary	b	10 digits
Oct EXE	Octal	o	10 digits
Dec EXE	Decimal	d	10 digits
Hex EXE	Hexadecimal	h	8 digits

Bin = log
Oct = ln
Dec = √
Hex = x^2

•Specifying the Number System for a Specific Value

No matter what standard number system is now specified, you can still input a value from another number system. The following shows which keys you should press for each number system immediately before you input the value.

Input	Number System
SHIFT b	Binary
SHIFT o	Octal
SHIFT d	Decimal
SHIFT h	Hexadecimal

b = log
o = ln
d = √
h = x^2

The number system you specify is applicable only for the value you input immediately following the above specifications.

You must specify the number system when you input a value whenever any of the numbers used in the value are outside the range of the currently specified standard number system. The following shows the values which are valid in the number systems used by this calculator.

Number System	Valid 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

■ Converting Number Systems

You can convert a value from one number system to another using one of two different methods by specifying the applicable number system.

•Converting to the Standard Number System

① Specify the standard number system.

② Enter the number system for a value and input the value.

③ Press the EXE key.

Example	Operation	Display
Decimal equivalent of $2A_{16}$ and 274_8	Dec EXE → "d"	
	SHIFT h 2A EXE	42. d
	SHIFT o 274 EXE	188. d
Hexadecimal equivalent of 123_{10} and 1010_2	Hex EXE → "h"	
	SHIFT d 123 EXE	7b. h
	SHIFT b 1010 EXE	A. h
Octal equivalent of 15_{16} and 1100_2	Oct EXE → "o"	
	SHIFT h 15 EXE	25. o
	SHIFT b 1100 EXE	14. o
Binary equivalent of 36_{10} and $2C3B7_{16}$	Bin EXE → "b"	
	SHIFT d 36 EXE	100100. b
	SHIFT h 2C EXE	101100. b

•Converting from the Standard Number System

① Specify the standard number system.

② Enter a value (of the standard number system).

③ Press the EXE key.

④ Specify a different standard number system.

⑤ Press the EXE key.
The displayed value changes to the number system specified in this step.

Example	Operation	Display
	Dec EXE → "d"	
	22 EXE	22. d
Binary equivalene of 22_{10}	Bin EXE	10110. b
Octal equivalent of 22_{10}	Oct EXE	26. o
Hexadecimal equivalent of 22_{10}	Hex EXE	16. h

■ Converting to a Negative Value

Use the Neg key to get the negative equivalent of a binary, octal, or hexadecimal value, expressed as its twos' complement.

Example	Operation	Display
Negative of 110010_2	Bin EXE → "b"	
	Neg 110010 EXE	1111001110. b
Negative of 72_8	Oct EXE → "o"	
	Neg 72 EXE	7777777706. o
Negative of $3A_{16}$	Hex EXE → "h"	
	Neg 3A EXE	FFFFFFC6. h

■ Using Basic Arithmetic Operations

You can add, subtract, multiply and divide using values of different number systems. Remember, that decimals are cut off in the Base-*n* mode.

Example	Operation	Display
$10111_2+11010_2=110001_2$	[Bin] [EXE] → "b"	
	10111 [+] 11010 [EXE]	110001. b
$B47_{16}-DF_{16}=A68_{16}$	[Hex] [EXE] → "h"	
	B47 [−] DF [EXE]	A68. h
$123_8 \times ABC_{16}=37AF4_{16}$	[SHIFT] [o] 123 [×] ABC [EXE]	37AF4. h
$=228084_{10}$	[Dec] [EXE]	228084. d
$1F2D_{16}-100_{10}=7881_{10}$	[SHIFT] [h] 1F2D [−] 100 [EXE]	7881. d
$=1EC9_{16}$	[Hex] [EXE]	1EC9. h
$7654_8 \div 12_{10}=334.3333333_{10}$	[Dec] [EXE] → "d"	
$=516_8$	[SHIFT] [o] 7654 [÷] 12 [EXE]	334. d
	[Oct] [EXE]	516. o
$1234_{10}+1EF_{16} \div 24_8=2352_8$	[SHIFT] [d] 1234 [+] [SHIFT] [h] 1EF	
$=1258_{10}$	[÷] 24 [EXE]	2352. o
	[Dec] [EXE]	1258. d

■ Using Logical Operations

Logical operations are performed using the [and] key for logical product, the [or] key for logical sum, the [Not] key for negation, and the [xor] key for exclusive logical sum.

Example	Operation	Display
19_{16}AND$1A_{16}=18_{16}$	[Hex][EXE] → "h"	
	19[and]1A[EXE]	18. h
1110_2AND$36_8=1110_2$	[Bin][EXE] → "b"	
	1110[and][SHIFT][o]36[EXE]	1110. b
23_8OR$61_8=63_8$	[Oct][EXE] → "o"	
	23[or]61[EXE]	63. o
120_{16}OR$1101_2=12D_{16}$	[Hex][EXE] → "h"	
	120[or][SHIFT][b]1101[EXE]	12d. h
1010_2AND$(A_{16}$OR$7_{16})=1010_2$	[Bin][EXE] → "b"	
	1010[and][(][SHIFT][h]A[or][SHIFT][h]	
	7[)][EXE]	1010. b
5_{16}XOR$3_{16}=6_{16}$	[Hex][EXE] → "h"	
	5[SHIFT][xor]3[EXE]	6. h
Negation of 1234_8	[Oct][EXE] → "o"	
	[Not]1234[EXE]	7777776543. o
Negation of $2FFFED_{16}$	[Hex][EXE] → "h"	
	[Not]2FFFED[EXE]	FFd00012. h

3-6 Performing Statistical Calculations

The statistical functions of your Casio calculator simplify a wide variety of commonly used statistical operations. The actual formulas used by the calculator for internal statistical calculations can be found in Appendix C. Statistical calculations are divided into two types: standard deviation which is performed in the SD mode, and regression calculation which is performed in the LR mode.

■ Performing Standard Deviation

Once you input a set of data in the SD mode, you can quickly calculate two types of standard deviation, the mean, the number of data, the sum of the data, and the sum of squares of the data.

It should be noted that some calculation results are automatically stored in certain constant memories as noted below. This means that any values previously stored in these memories are lost.

Memory	Calculation Result
K1	Sum of squares
K2	Sum of data
K3	Number of data items

Inputting data

① Press MODE × for the SD mode.

② Press SHIFT Scl EXE to clear the statistical memories.

③ Input data items one-by-one by pressing the DT key after each input.

If you have a number of data items which are identical, you can input them as a group using one of two different procedures.

Example 1

Data: 10, 20, 20, 30

Input: 10 DT 20 DT DT 30 DT

Each time you press DT without inputting a new data item, the previously input data item (here, 20) is input again.

Example 2

Data: 10, 20, 20, 20, 20, 20, 20, 30

Input: 10 [DT] 20 [SHIFT] [;] 6 [DT] 30 [DT]

The value which you input after the semicolon (here, 6) tells the calculator how many times to repeat the previously input data item (here, 20).

Deleting an input data item

The method you used to delete in data depends upon when and how the data were input.

Example 1

40 [DT] 20 [DT] 30 [DT] 50 [DT]

To clear 50, press the [cl] key.

Example 2

40 [DT] 20 [DT] 30 [DT] 50 [DT]

To clear 20, press 20 [cl].

Example 3

30 [DT] 50 [DT] 120 [SHIFT] [;]

To clear 120 [SHIFT] [;], press [AC].

Example 4

30 [DT] 50 [DT] 120 [SHIFT] [;] 31

To clear 120 [SHIFT] [;] 31, press [AC].

Example 5

30 [DT] 50 [DT] 120 [SHIFT] [;] 31 [DT]

To clear 120 [SHIFT] [;] 31 [DT], press [cl].

Example 6

50 [DT] 120 [SHIFT] [;] 31 [DT] 40 [DT] 30 [DT]

To clear 120 [SHIFT] [;] 31 [DT], press 120 [SHIFT] [;] 31 [cl].

Performing calculations

Perform the following operations in any sequence to display the results noted.

Key Operation	Result
SHIFT $x\sigma_n$ EXE	Standard deviation σ_n
SHIFT $x\sigma_{n-1}$ EXE	Standard deviation σ_{n-1}
SHIFT $\bar{x}$ EXE	Mean
SHIFT IK 1 EXE	Sum of squares
SHIFT IK 2 EXE	Sum
SHIFT IK 3 EXE	Number of data

$x\sigma_n$ = 2
$x\sigma_{n-1}$ = 3
$\bar{x}$ = 1
IK = Prog

Example	Operation	Display
Data: 55, 54, 51, 55, 53, 53, 54, 52	MODE × →"SD"	
	SHIFT Scl EXE (Memory clear)	
	55 DT 54 DT 51 DT 55 DT 53 DT DT	
	54 DT 52 DT	52.
	(Standard deviation σ_n) SHIFT $x\sigma_n$ EXE	1. 316956719
	(Standard deviation σ_{n-1}) SHIFT $x\sigma_{n-1}$ EXE	1. 407885953
	(Mean) SHIFT $\bar{x}$ EXE	53. 375
	(Number of data n) SHIFT IK 3 EXE	8.
	(Sum) SHIFT IK 2 EXE	427.
	(Sum of squares) SHIFT IK 1 EXE	22805.
Deviation of unbiased variance for above data	SHIFT $x\sigma_{n-1}$ x^2 EXE	1. 982142857
Difference between mean and each data item	55 − SHIFT $\bar{x}$ EXE	1. 625
	54 − SHIFT $\bar{x}$ EXE	0. 625
	51 − SHIFT $\bar{x}$ EXE	−2. 375
	⋮	⋮
$\bar{x}$ and $x\sigma_{n-1}$ for following data	SHIFT Scl EXE	
	110 SHIFT ; 10 DT	110.
	130 SHIFT ; 31 DT	130.
	150 SHIFT ; 24 DT	150.
	170 DT DT	170.
	190 DT DT DT	190.
	SHIFT IK 3 EXE	70.
	SHIFT $\bar{x}$ EXE	137. 7142857
	SHIFT $x\sigma_{n-1}$ EXE	18. 42898069

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

■ Performing Regression Calculations

Once you input a set of data in the LR mode, you can perform linear, logarithmic, exponential and power regression.
It should be noted that some calculation results are automatically stored in certain constant memories as noted below. This means that any values previously stored in these memories are lost.

Memory	Calculation Result
K1	Sum of squares of x-data
K2	Sum of x-data
K3	Number of data items
K4	Sum of squares of y-data
K5	Sum of y-data
K6	Sum of x and y-data

•Linear Regression

Inputting data

① Press [MODE] [◢] for the LR mode.

② Press [SHIFT] [Scl] [EXE] to clear the statistical memories.

③ Input data pairs using the following operation:
⟨x-data⟩ [SHIFT] [,] ⟨y-data⟩ [DT]

If you have a number of data pairs which are identical, you can input them as a group using one of two different procedures.

Example 1

Data: 10/20, 20/30, 20/30, 40/50

Input: 10 [SHIFT] [,] 20 [DT]
20 [SHIFT] [,] 30 [DT]
[DT]
40 [SHIFT] [,] 50 [DT]

Each time you press [DT] without inputting a new data pair, the previously input data pair (here, 20/30) is input again.

Example 2

Data: 10/20, 20/30, 20/30, 20/30, 20/30, 20/30, 40/50

Input: 10 SHIFT , 20 DT
20 SHIFT , 30 SHIFT ; 5 DT
40 SHIFT , 50 DT

The value which you input after the semicolon (here, 5) tells the calculator how many times to repeat the previously input data pair (here, 20/30).

Deleting an input data pair

The method you used to delete in data depends upon when and how the data were input.

Example 1

10 SHIFT , 40 DT
20 SHIFT , 20 DT
30 SHIFT , 30 DT
40 SHIFT , 50
To clear 40 SHIFT , 50, press the AC key.

Example 2

10 SHIFT , 40 DT
20 SHIFT , 20 DT
30 SHIFT , 30 DT
40 SHIFT , 50 DT
To clear 40 SHIFT , 50 DT, press the cl key.

Example 3

10 SHIFT , 40 DT
20 SHIFT , 20 DT
30 SHIFT , 30 DT
40 SHIFT , 50 DT
To clear 20 SHIFT , 20 DT, press 20 SHIFT , 20 cl.

Performing calculations

Perform the following operations in any sequence to display the results noted.

Key Operation	Result	
SHIFT A EXE	Constant term A	A = 7
SHIFT B EXE	Regression coefficient B	B = 8
SHIFT r EXE	Correlation coefficient r	r = 9
SHIFT $\hat{x}$ EXE	Estimated value of x	$\hat{x}$ = ×
SHIFT $\hat{y}$ EXE	Estimated value of y	$\hat{y}$ = ÷

Example	Operation	Display
Temperature and length of steel bar	MODE ÷ →"LR"	
	SHIFT Scl EXE (Memory clear)	
	10 SHIFT , 1003 DT	10.
	15 SHIFT , 1005 DT	15.
	20 SHIFT , 1010 DT	20.
	25 SHIFT , 1011 DT	25.
	30 SHIFT , 1014 DT	30.
Covariance: $\frac{\Sigma xy - n \cdot \bar{x} \cdot \bar{y}}{n-1}$	(Constant term A) SHIFT A EXE	997. 4
	(Regression coefficient B) SHIFT B EXE	0. 56
	(Correlation coefficient r) SHIFT r EXE	0. 982607368
	(Length at 18°C) 18 SHIFT $\hat{y}$ EXE	1007. 48
	(Temperature at 1000mm) 1000 SHIFT $\hat{x}$ EXE	4. 642857143
	(Critical coefficient) SHIFT r x^2 EXE	0. 965517241
	(Covariance) (SHIFT IK 6 − SHIFT IK 3 × SHIFT $\bar{x}$ × SHIFT $\bar{y}$) ÷ (SHIFT IK 3 − 1) EXE	35.

Temp.	Length
10°C	1003mm
15°C	1005mm
20°C	1010mm
25°C	1011mm
30°C	1014mm

•Logarithmic Regression

The regression formula used for logarithmic regression is $y = A + B \cdot \ln x$.

Inputting data

① Press [MODE] [÷] for the LR mode.

② Press [SHIFT] [Scl] [EXE] to clear the statistical memories.

③ Input data pairs using the following operation:
[ln] ⟨x-data⟩ [SHIFT] [,] ⟨y-data⟩ [DT]

If you have a number of data pairs which are identical, you can input them as a group using the two procedures described for linear regression. Don't forget to press the [ln] key before inputting x-data.

Deleting an input data pair

You can delete input data pairs using the same procedures described for linear regression. Again, don't forget to press the [ln] key before inputting x-data.

Performing calculations

Perform the following operations in any sequence to display the results noted.

Key Operation	Result
[SHIFT] [A] [EXE]	Constant term A
[SHIFT] [B] [EXE]	Regression coefficient B
[SHIFT] [r] [EXE]	Correlation coefficient r
y [SHIFT] [$\hat{x}$] [EXE] [SHIFT] [e^x] [SHIFT] [Ans] [EXE]	Estimated value of x
[ln] x [SHIFT] [$\hat{y}$] [EXE]	Estimated value of y

[A] = [7]
[B] = [8]
[r] = [9]
[$\hat{x}$] = [×]
[$\hat{y}$] = [÷]

It should also be noted that other calculation results are different from those produced by linear regression as follows.

Linear Regression	Logarithmic Regression
Sum of x-data	Sum of logs of x-data
Sum of squares of x-data	Sum of squares of logs of x-data
Sum of x and y-data	Sum of y and logs of x-data

Example: xi	Example: yi	Operation	Display
		[MODE][/]→"LR"	
		[SHIFT][Scl][EXE]	
29	1.6	[ln]29[SHIFT][,]1.6[DT]	3.36729583
50	23.5	[ln]50[SHIFT][,]23.5[DT]	3.912023005
74	38.0	[ln]74[SHIFT][,]38.0[DT]	4.304065093
103	46.4	[ln]103[SHIFT][,]46.4[DT]	4.634728988
118	48.9	[ln]118[SHIFT][,]48.9[DT]	4.770684624
		(Constant term A) [SHIFT][A][EXE]	−111.1283976
		(Regression coefficient B) [SHIFT][B][EXE]	34.02014749
		(Correlation coefficient r) [SHIFT][r][EXE]	0.994013946
		($\hat{y}$ when $xi=80$) [ln]80[SHIFT][$\hat{y}$][EXE]	37.94879482
		($\hat{x}$ when $yi=73$) 73[SHIFT][$\hat{x}$][EXE][SHIFT][e^x][SHIFT][Ans][EXE]	224.1541314

•Exponential Regression

The regression formula used for exponential regression is $y = A \cdot e^{B \cdot x}$ ($\ln y = \ln A + Bx$).

Inputting data

① Press MODE ⧄ for the LR mode.

② Press SHIFT Scl EXE to clear the statistical memories.

③ Input data pairs using the following operation:
⟨x-data⟩ SHIFT , ln ⟨y-data⟩ DT

If you have a number of data pairs which are identical, you can input them as a group using the two procedures described for linear regression. Don't forget to press the ln key before inputting y-data.

Deleting an input data pair

You can delete input data pairs using the same procedures described for linear regression. Again, don't forget to press the ln key before inputting y-data.

Performing calculations

Perform the following operations in any sequence to display the results noted.

Key Operation	Result	
SHIFT e^x SHIFT A EXE	Constant term A	A = 7
SHIFT B EXE	Regression coefficient B	B = 8
SHIFT r EXE	Correlation coefficient r	r = 9
ln y SHIFT $\hat{x}$ EXE	Estimated value of x	$\hat{x}$ = ⊠
x SHIFT $\hat{y}$ EXE SHIFT e^x SHIFT Ans EXE	Estimated value of y	$\hat{y}$ = ⧄

It should also be noted that other calculation results are different from those produced by linear regression as follows.

Linear Regression	Exponential Regression
Sum of y-data	Sum of logs of y-data
Sum of squares of y-data	Sum of squares of logs of y-data
Sum of x and y-data	Sum of x and logs of y-data

Example: xi	Example: yi	Operation	Display
		[SHIFT][Sci][EXE]	
6.9	21.4	6.9[SHIFT][,][ln]21.4[DT]	6. 9
12.9	15.7	12.9[SHIFT][,][ln]15.7[DT]	12. 9
19.8	12.1	19.8[SHIFT][,][ln]12.1[DT]	19. 8
26.7	8.5	26.7[SHIFT][,][ln]8.5[DT]	26. 7
35.1	5.2	35.1[SHIFT][,][ln]5.2[DT]	35. 1
		(Constant term A) [SHIFT][e^x][SHIFT][A][EXE]	30. 49758742
		(Regression coefficient B) [SHIFT][B][EXE]	−0. 049203708
		(Correlation coefficient r) [SHIFT][r][EXE]	−0. 997247351
		($\hat{y}$ when $xi=16$) 16[SHIFT][$\hat{y}$][EXE][SHIFT][e^x][SHIFT][Ans][EXE]	13. 87915739
		($\hat{x}$ when $yi=20$) [ln]20[SHIFT][$\hat{x}$][EXE]	8. 574868046

•Power Regression

The regression formula used for power regression is $y = A \cdot x^B$ ($\ln y = \ln A + B \ln x$).

Inputting data

① Press [MODE] [⁄] for the LR mode.

② Press [SHIFT] [Scl] [EXE] to clear the statistical memories.

③ Input data pairs using the following operation:
[ln] ⟨x-data⟩ [SHIFT] [,] [ln] ⟨y-data⟩ [DT]

If you have a number of data pairs which are identical, you can input them as a group using the two procedures described for linear regression. Don't forget to press the [ln] key before inputting x-data and y-data.

Deleting an input data pair

You can delete input data pairs using the same procedures described for linear regression. Again, don't forget to press the [ln] key before inputting x-data and y-data.

Performing calculations

Perform the following operations in any sequence to display the results noted.

Key Operation	Result	
[SHIFT] [e^x] [SHIFT] [A] [EXE]	Constant term A	[A] = [7]
[SHIFT] [B] [EXE]	Regression coefficient B	[B] = [8]
[SHIFT] [r] [EXE]	Correlation coefficient r	[r] = [9]
[ln] y [SHIFT] [$\hat{x}$] [EXE] [SHIFT] [e^x] [SHIFT] [Ans] [EXE]	Estimated value of x	[$\hat{x}$] = [×]
[ln] x [SHIFT] [$\hat{y}$] [EXE] [SHIFT] [e^x] [SHIFT] [Ans] [EXE]	Estimated value of y	[$\hat{y}$] = [⁄]

It should also be noted that other calculation results are different from those produced by linear regression as follows.

Linear Regression	Power Regression
Sum of y-data	Sum of logs of y-data
Sum of squares of y-data	Sum of squares of logs of y-data
Sum of x and y-data	Sum of logs of x and y-data

Example	Operation	Display
	SHIFT Scl EXE	
xi = 28, yi = 2410	ln 28 SHIFT , ln 2410 DT	3. 33220451
xi = 30, yi = 3033	ln 30 SHIFT , ln 3033 DT	3. 401197382
xi = 33, yi = 3895	ln 33 SHIFT , ln 3895 DT	3. 496507561
xi = 35, yi = 4491	ln 35 SHIFT , ln 4491 DT	3. 555348061
xi = 38, yi = 5717	ln 38 SHIFT , ln 5717 DT	3. 63758616
	(Constant term A) SHIFT e^x SHIFT A EXE	0. 238801082
	(Regression coefficient B) SHIFT B EXE	2. 771866148
	(Correlation coefficient r) SHIFT r EXE	0. 998906256
	($\hat{y}$ when $xi=40$) ln 40 SHIFT $\hat{y}$ EXE SHIFT e^x SHIFT Ans EXE	6587. 674743
	($\hat{x}$ when $yi=1000$) ln 1000 SHIFT $\hat{x}$ EXE SHIFT e^x SHIFT Ans EXE	20. 26225659

3-7 Using Scientific Constants in Calculations

You can use any of the 13 scientific constants programmed in the memory of the calculator. Constants are selected by using the following operations.

Operation	Item	Symbol	Value	Unit
[ALPHA] [CONST] [c]	Speed of light in vacuum	c	299792458	ms^{-1}
[ALPHA] [CONST] [h]	Planck's constant	h	6.626176×10^{-34}	J.S
[ALPHA] [CONST] [G]	Gravitational constant	G	6.672×10^{-11}	Nm^2kg^{-2}
[ALPHA] [CONST] [e]	Elementary charge	e	1.6021892×10^{-19}	C
[ALPHA] [CONST] [me]	Electron rest mass	me	9.109534×10^{-31}	kg
[ALPHA] [CONST] [u]	Atomic mass unit	u	1.6605655×10^{-27}	kg
[ALPHA] [CONST] [NA]	Avogadro constant	N_A	6.022045×10^{23}	mol^{-1}
[ALPHA] [CONST] [k]	Boltzmann constant	k	1.380662×10^{-23}	$J.K^{-1}$
[ALPHA] [CONST] [Vm]	Molar volume of ideal gas at s.t.p.	Vm	0.02241383	m^3mol^{-1}
[ALPHA] [CONST] [g]	Accelaration of free fall	g	9.80665	ms^{-2}
[ALPHA] [CONST] [R]	Molar gas constant	R	8.31441	$Jmol^{-1}K^{-1}$
[ALPHA] [CONST] [εo]	Permittivity of vacuum	ϵo	$8.854187818\times10^{-12}$	Fm^{-1}
[ALPHA] [CONST] [μo]	Permeability of vacuum	μo	1.256637061×10^{-6}	Hm^{-1}

[CONST] = [ln]　[c] = [1]　[e] = [4]　[NA] = [7]　[g] = [+]　[μo] = [÷]
[h] = [2]　[me] = [5]　[k] = [8]　[R] = [−]
[G] = [3]　[u] = [6]　[Vm] = [9]　[εo] = [×]

Example	Operation	Display
Speed of light in vacuum (c) Obtain the energy when a substance having a mass of 2g is consumed and completely converted to energy. Formula: $E=mc^2$	2 [EXP] [(−)] 3 [×] [ALPHA] [CONST] [c] [x^2] [EXE]	1.797510357^{14}
Planck's constant (h) Obtain the energy lost when an atom gives off one photon with a wavelength of $\lambda=5.0\times10^{-7}$m. Formula: $E=h\frac{c}{n}$	[ALPHA] [CONST] [h] [×] [ALPHA] [CONST] [c] [÷] 5 [EXP] [(−)] 7 [EXE]	3.97295518^{-19}

Example	Operation	Display
Gravitational constant (G) What is the force of attraction of two people weighing 60 kg and 80 kg separated by a distance of 70 cm? Formula: $F=G\frac{Mm}{r^2}$	[ALPHA] [CONST] [G] [×] 60 [×] 80 [÷] 0.7 [x^2] [EXE]	6.535836735^{-07}
Elementary charge (e) **Electron rest mass (me)** Obtain the sustained force and acceleration of electrons between two parallel electrodes 3 cm apart when a voltage of 200 V is applied. Formula: $F=eE$ $a=\frac{F}{me}$	[ALPHA] [CONST] [e] [×] 200 [÷] 0.03 [EXE] (Continuing) [÷] [ALPHA] [CONST] [me] [EXE]	1.068126133^{-15} 1.172536524^{15}
Atomic mass unit (u) The mass of a hydrogen atom is 1.00783amu and the electron mass is 1/1800 of this. What is the proton mass?	[(] 1.00783 [−] 1.00783 [÷] 1800 [)] [×] [ALPHA] [CONST] [u] [EXE]	1.672637968^{-27}
Avogadro constant (N_A) Obtain the mass of one molecule of water.	18 [÷] [ALPHA] [CONST] [NA] [EXE]	2.98901785^{-23}
Boltzmann constant (k) Obtain the average translational motion energy of one molecule of ideal gas at 0°C. Formula: $e=\frac{3}{2}kT$	3 [÷] 2 [×] [ALPHA] [CONST] [k] [×] 273 [EXE]	5.65381089^{-21}
Molar volume of ideal gas at s.t.p. (Vm) How many molecules exist per cc in a vacuum at 0°C at a pressure of 10^{-7}mHg?	[ALPHA] [CONST] [NA] [×] 1 [EXP] [(−)] 7 [÷] 760 [×] 1 [EXP] [(−)] 6 [÷] [ALPHA] [CONST] [Vm] [EXE]	3535202784.
Accelaration of free fall (g) A pebble was dropped and took 1.5 seconds to hit the surface of a pond. Find the distance of fall. Formula: $S=\frac{1}{2}gt^2$	[ALPHA] [CONST] [g] [×] 1.5 [x^2] [÷] 2 [EXE]	11.03248125

Example	Operation	Display
Molar gas constant (R) An inflated rubber balloon is 2.5 atm. in pressure, 2.8 liters in volume, and 37°C in inside temperature. What is the total number of gas molecules in the balloon? Formula: $N=\frac{PV}{RT}\cdot N_A$	2.5 [×] 1.013 [EXP] 5 [×] 2.8 [EXP] [(−)] 3 [÷] [ALPHA] [CONST] [R] [÷] [(] 273 [+] 37 [)] [×] [ALPHA] [CONST] [NA] [EXE]	1.656755234^{23}
Permittivity of vacuum (ϵ_0) Here is a condenser formed by two 700 cm² copper plates held parallel and 2 mm apart. When it is placed in oil whose specific inductive capacity is 5, what is the capacitance of the condenser?	5 [×] [ALPHA] [CONST] [ε_0] [×] 700 [EXP] [(−)] 4 [÷] 2 [EXP] [(−)] 3 [EXE]	1.549482868^{-09}
Permeability of vacuum (μ_0) In a vacuum, two long conductors are stretched parallel and 0.4 m apart. When 2A and 3A of currents flow in opposite directions in the two conductors, what is the force (N) exerting on 2-m sections of the conductors?	[ALPHA] [CONST] [μ_0] [×] 3 [×] 2 [÷] [SHIFT] [π] [÷] 0.4 [EXE]	$6.^{-06}$

Chapter 4

Built-in Formula Calculations

$$S=\frac{\pi r^2\theta}{360}$$

$$Q(x)=\frac{1}{\sqrt{2\pi}}\int_0^{|x|}e^{-\frac{t^2}{2}}dt$$

$$P_x=\frac{{}_kC_x\cdot{}_{N-k}C_{n-x}}{{}_NC_n}$$

$$S=\frac{1}{2}ah$$

$$P_x={}_nC_x\,P^x\,(1-P)^{n-x}$$

$$R_1=Z_0\sqrt{1-\frac{Z_0}{Z_0}}\text{、}\;R_2=\frac{Z_1}{\sqrt{1-\frac{Z_1}{Z_0}}}$$

4-1 Using Built-in Formula Calculations

Your Casio calculator is programmed with 128 built-in formulas that you can easily recall by entering the correct formula numbers.

■ Recalling Built-in Formulas

You can recall built-in formulas either by entering the correct formula number or by sequentially searching through the built-in formulas until you find the one you need.

•Recalling a Built-in Formula Using Its Formula Number

You can recall any specific built-in formula by inputting its formula number.

① Input the number of the built-in formula you wish to recall.

② Press the [FMLA] key.

Example

Recall Heron's formula, which is built-in formula number 5.

5 [FMLA]

```
S=√(s(s-a)(s-b→
a?             0.
```

•Sequentially Searching Through Built-in Formulas

You can also search sequentially through the built-in formulas available by pressing the [FMLA] key without inputting a number.

Example

Recall built-in formula number 1 and then search through the next sequential formulas.

1 [FMLA]

(Formula number 1)

```
ax²+bx+c=0
 a?            0.
```

[FMLA]

(Formula number 2)

```
a1x+b1y=c1 a2x→
a1?            0.
```

[FMLA]

(Formula number 3)

```
a1x+b1y+c1z=d1→
a1?            0.
```

**Pressing [SHIFT] [FMLA] returns to the previous formula.*

■ Canceling a Built-in Formula Recall

After you have recalled a built-in formula, you can cancel it at any time by pressing MODE 1. This switches to manual calculations, and the computer stands by waiting for further input.

■ Inputting Values for Built-in Formula Variables

Once a built-in formula is recalled, the next step is to input values for variables. The variables appear on the display with a question mark to request that you input a numeric value.

Example

Quadratic equation solution

	Key	Display
① Specify built-in formula number 1 for quadratic equation solution.	1 FMLA	ax²+bx+c=0 a? 0.
② Enter a value for a.	2	2_ a? 0.
	EXE	ax²+bx+c=0 b? 0.
③ Enter a value for b.	5	5_ b? 0.
	EXE	ax²+bx+C=0 c? 0.
④ Enter a value for c. The variable d is a dummy prompt.	3	3_ c? 0.
	EXE	ax²+bx+c=0 d= 0.

Dummy prompts appear for built-in formula numbers 1 through 3 and should be ignored. Simply press the EXE key when they appear.

■ Obtaining the Result of a Built-in Formula

After you enter values for all of the variables which appear on the display, you can execute the formula by pressing the [EXE] key.

Example

Continuing from the previous example.

① Press the [EXE] key.

[EXE]

```
ax²+bx+c=0       Disp      D
◂ x=                     -1.
```

Notice that the Disp symbol appears, along with an arrow on the left side of the display. This indicates that there are other values in the solution set.

② Press the [EXE] key.

[EXE]

```
ax²+bx+c=0                 D
  x=                     -1.5
```

Press [EXE] as many times as required to view all of the values which satisfy the formula.

•Displaying the Built-in Formula When Inputting Values

Notice that when you input a value for a variable, the prompt remains on the bottom of the display, and the formula on the top of the display is replaced by the value that you input. You make the formula return to the top of the display as follows.

Example

3

```
3_
                           D
  c?                       0.
```

[SHIFT] [LOOK]

```
ax²+bx+c=0                 D
  c?                       0.
```

Now if you press [EXE], the value 3 is input for c. If you press [SHIFT] [LOOK] again, the display again shows the input value and the variable prompt.

[SHIFT] [LOOK]

```
3_
                           D
  c?                       0.
```

•Shifting the Built-in Formula on the Display

Some of the built-in formulas contained in the memory of the calculator are longer than the 14 columns on the display. In this case, you can shift the formula to the left and right on the display to read it.

Example

① Recall built-in formula number 41.

AC 41 FMLA

```
a=(V2-V1)/(t2-→
V2?           0.
```

② Press the ⇨ key to shift to the right.

⇨⇨

```
←(V2-V1)/(t2-t1→
V2?           0.
```

⇨⇨

```
←2-V1)/(t2-t1)
V2?           0.
```

Indicators on the display below the formula show you the direction that the currently displayed formula continues.

③ Press the ⇦ key to shift to the left.

⇦⇦⇦⇦

```
a=(V2-V1)/(t2-→
V2?           0.
```

■ Executing the Same Built-in Formula Again

After you have obtained the result of a formula, you can press the EXE key again to execute the formula again from the beginning. Each variable of the formula is displayed one by one, while still retaining the values that you assigned to it previously. You can either press the EXE key to keep the same value, or input a new value.

■ What to Do When an Error Is Generated

The action you should take when an error is generated depends upon whether you are still inputting values or whether you are executing the formula.
When an Ma error or Syn error appears while you are inputting values:

① Press either the ⇦ or ⇨ key (it doesn't matter which).
**Use the ⇦ and ⇨ keys when you only want to make changes. If you want to clear all of the values which you have input up to that point and start over again, press the AC key and continue.*

② Make the required corrections.
**Corrections are made using the delete and insert procedures described in 2-2 Correcting Entries on the Display.*

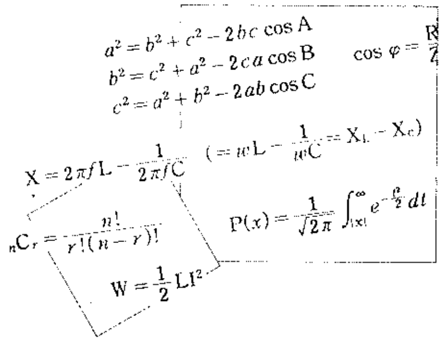
When an error appears while you are executing the formula:

① Press the AC key.

You can't use the ⇦ and ⇨ keys in this case for partial changes.

② Press the FMLA key.
**This executes the formula again, after clearing all of the values that you input before the error was generated.*

Chapter 5
User Formula Calculations



5-1 About User Formulas

Of course, it is very possible that you might need to use a formula which is not in the memory of the calculator. In this case, you can input a formula and either execute it once or store it in memory until you need it. You can also recall one of the built-in formulas, make any changes in it you want and then use it as a new user formula.

■ Chaining a Series of Calculations in a Formula

As with manual calculations, you can chain multiple formulas into a series that is treated as a single calculation sequence. You can use one of three different symbols to connect each calculation in the chain. Chained calculations are performed one-by-one, in the same left-to-right sequence as they would appear when written down.

In all cases, the ◀ indicator appears on the display to let you know that the calculator is waiting for you to press the EXE key to continue.

" : " — This connector tells the calculator to pause until the EXE key is pressed, and retains the values which have been assigned to variables.

Example

C=A+B : D=A+B

① Input of value for A (ex. 10).

② Input of value for B (ex. 20).

③ Display of C (30) and stop.

④ Press EXE.

⑤ Display of D (30).

" ◢ " —This connector tells the calculator to pause until the EXE key is pressed, and clears the values which have been assigned to variables.

Example

C=A+B ◢ D=A+B

① Input of value for A (ex. 10).

② Input of value for B (ex. 20).

③ Display of C (30) and stop.

④ Press EXE.

⑤ Input of value for A (ex. 30).

⑥ Input of value for B (ex. 40).

⑦ Display of D (70).

" ⌋ " —This connector tells the calculator to clear the values which have been assigned to variables, without displaying any intermediate results.

Example

C = A + B ⌋ D = A + B

① Input of value for A (ex. 10).

② Input of value for B (ex. 20).

③ Input of value for A (ex. 30).

④ Input of value for B (ex. 40).

⑤ Display of D (70).

Note that each portion of a chained series is actually an individual calculation. This means that you couldn't use a sequence such as the following:

123 × 456 : + 5

5-2 Using Manually Entered User Formulas

You can input user formulas for one-time execution without storing them in memory. These are called *manually entered user formulas*. Such formulas are input in the following format:

Variable = Formula

Example

Manually input the user formula: M = (A + B) / 2

AC ALPHA M SHIFT = (ALPHA A + ALPHA B) ÷ 2 EXE	M= (A+B) / 2 A? 0.
56	56_ A? 0.
EXE	M= (A+B) / 2 B? 0.
65	65_ B? 0.
EXE	M= (A+B) / 2 M= 60.5

5-3 Understanding User Formula Memories

Your Casio calculator comes equipped with a total of 12 independent memories for storage of user formulas. When the calculator is in the WRT mode (activated by MODE 2), the display should look something like this:

P 0123456789AB
WRT
S = 675

The top line shows the formula memories which are empty and ready for storage. We refer to these memories using such names as memory P1, memory P2, memory PA, etc. Each time you store a formula in one of the memories, the name of the memory you use is replaced on this display with a dash.

The number on the bottom line of the display shows the number of formula steps remaining in the entire user formula memory. This is a very important point.
******You can store as much as you like in any one user formula memory, as long as the total number of formula steps stored in all of the user formula memories is not greater than 675.*

The display used here shows that the user formula memories are all empty. Each time you store a formula in one of the memories the number on this display becomes smaller. As you input formulas, the input position is always indicated by a blinking cursor. When there are six or fewer formula steps remaining in memory, the cursor changes to ■, and input becomes impossible when all of the steps are used up. Should this happen, delete no longer necessary formulas from memory to make more room.

For important details on counting formula steps, see Appendix C.

5-4 Using User Formula Memories

■ Storing an Original Formula

Unlike the manual mode, when you store a formula in a user formula memory it remains there until you delete it. The contents of the user memories are retained even when you press the [AC] key or switch the power of the calculator OFF.

① Press [MODE] [2] to switch to the WRT mode.

② Use the [⇦] and [⇨] keys to select a formula memory name.
**The currently selected formula memory is indicated by its name flashing on the display. The [⇦] and [⇨] keys move the selection over to the left and right. Of course, you can skip this step if the currently blinking formula memory name is the one you wish to use.*

③ Specify a calculation mode for the selected formula memory.

The following lists the key operation and restrictions for each calculation mode.

Comp [MODE] [+]
Base-*n* [MODE] [−]
•Scientific function calculations cannot be performed.
•Unit of angular measurement cannot be specified.
•Built-in formulas cannot be recalled.

SD [MODE] [×]
•Abs and $\sqrt[3]{\ }$ cannot be used.
•[DT] cannot be entered consectively.

LR [MODE] [÷]
•Abs and $\sqrt[3]{\ }$ cannot be used.
•[DT] cannot be entered consectively.

④ Press the [EXE] key.
**The display should appear as shown here. The 0 at the lower right shows how many steps there are between the present position of the cursor and the beginning of the formula. Since we have not input anything yet, this number indicates zero steps in memory.*

⑤ Input the formula using the same procedures as those explained in Chapter 3 Manual Calculations.
**Note that each time you input something, the number indicating the number of steps becomes bigger. If you use the [⇦] or [⇨] key to move the blinking cursor on the display, the number will change to indicate how many steps there are between the present position and the beginning of the formula.*

⑥ Press [MODE] [1] to store the program.

IMPORTANT

Note the following when writing formulas.

•You cannot include sexagesimal ⟷ decimal conversions in a formula.
•You cannot perform decimal place shift using the [ENG] key in a formula.

■ Modifying a Built-in Formula and Storing It as a User Formula

You can recall any of the 128 built-in formulas programmed in the memory of the calculator, modify it, and then store it in one of the user formula memories.

① Enter the built-in formula name and press the [FMLA] key.

Note that you select the built-in formula before you enter the WRT mode.

② Press [MODE] [2] to switch to the WRT mode.

③ Use the [⇐] and [⇒] keys to select a formula memory name.

The currently selected formula memory is indicated by its name flashing on the display. The [⇐] and [⇒] keys move the selection over to the left and right.

④ Press the [EXE] key.

⑤ Press the [FMLA] key to insert the built-in formula selected in step ① above.
If you wish to use more than one built-in formula, you would have to first go back to the RUN mode using [MODE] [1] to recall the built-in formula. Then you would repeat steps ① through ⑤ above to insert the next built-in formula into user formula memory. Repeat this procedure for each built-in formula you wish to insert.

⑥ Modify the recalled formula as desired.

⑦ Press [MODE] [1] to store the modified formula.

Example

Recall centrifugal force (1) to P0 and modify it.

Operation	Display
54 [FMLA] [MODE] 2	P 0123456789AB S = 675
[EXE]	_ WRT S = 0.
3 [→] [ALPHA] [SML] [M] [:]	3→m:_ WRT S = 4
[FMLA]	3→m:F=mrω²_ WRT S = 10
[+] 10	3→m:F=mrω²+10_ WRT S = 13

■ Executing a Formula Stored in a User Formula Memory

Once a formula is stored, it can be executed at any time by specifying the user formula memory name.

① Press MODE 1 to enter the RUN mode.

② Press Prog followed by the formula memory name.

③ Press the EXE key to execute the selected formula.

Once you execute a formula, subsequent operation depends on the type of formula that you recalled. For example, prompts may appear to tell you to input values for variables, etc.

Example

Execute the user formula which you stored in the previous example.

■ Deleting User Formulas

After you store formulas to the user memories, you can delete them either individually or all at once.

•Deleting a Specific User Formula

① Press MODE 3 to enter the PCL mode.
**You can delete user formulas in the PCL mode only.*

② Use the ⇦ and ⇨ keys to select a formula memory name.
**Memories which contain formulas are indicated by their memory names being replaced by a dash.*

③ Press the AC key to delete the selected user formula.
**After you press the AC key, the memory number where you deleted the formula will appear on the display again in place of the dash.*

④ Press MODE 1 to return to the RUN mode.

Example

Delete the formula in P3.

MODE 3	P 01__4_6789AB PCL S = 523
⇨⇨⇨	P 01__4_6789AB PCL S = 523
AC	P 01_34_6789AB S = 589

•Deleting All User Formulas

① Press MODE 3 to enter the PCL mode.

② Press SHIFT Mcl.

This deletes all user formulas, and causes all of the user formula memory names to appear on the display.

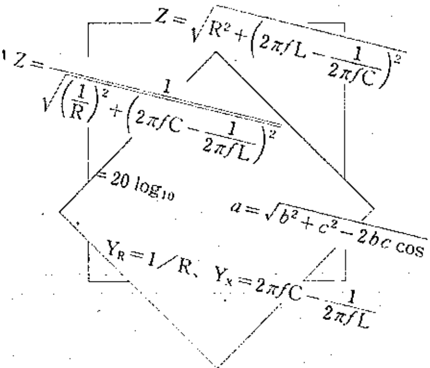
Example

Delete all formulas.

MODE 3	P 01__4_6789AB S = 523
SHIFT Mcl	P 0123456789AB S = 675

Chapter **6**

Formula Library



This chapter lists all of the built-in formulas which are programmed in your calculator. A short explanation of the formula is followed by a brief operational example.

1. Quadratic Equation Solution

$$ax^2+bx+c=0 \qquad (a \neq 0 \quad b^2-4ac \geqq 0)$$

• The quadratic equation can be solved when constants a, b and c are known.

Example

Solve: $2x^2+x-10=0$

Operation	Display
AC 1 FMLA (Recall quadratic equation solution.)	ax²+bx+c=0 a? 0.
2 EXE (Enter value for a.)	ax²+bx+c=0 b? 0.
1 EXE (Enter value for b.)	ax²+bx+c=0 c? 0.
(−) 1 0 EXE (Enter value for c.)	ax²+bx+c=0 d= 0.
EXE (d is a dummy.)	ax²+bx+c=0 x= 2.
EXE	ax²+bx+c=0 x= -2.5

2. Simultaneous Linear Equation with Two Unknowns

$$\begin{cases} a_1x + b_1y = c_1 \\ a_2x + b_2y = c_2 \end{cases} \quad \left(\begin{array}{l} a_1\ b_1\ c_1 \\ a_2\ b_2\ c_2 \\ a_1b_2 - b_1a_2 \neq 0 \end{array} \text{... are constants} \right)$$

- The simultaneous linear equation with two unknowns can be solved when a_1, b_1, c_1, a_2, b_2 and c_2 are known.

Example

Solve: $3x + 2y = 17$
$5x + 4y = 26$

Operation	Display
AC 2 FMLA (Recall simultaneous linear equation with two unknowns.)	a1x+b1y=c1 a2x → a1 ? 0.
3 EXE (Enter value for a_1.)	a1x+b1y=c1 a2x → b1 ? 0.
2 EXE (Enter value for b_1.)	a1x+b1y=c1 a2x → c1 ? 0.
1 7 EXE (Enter value for c_1.)	a1x+b1y=c1 a2x → a2 ? 0.
5 EXE (Enter value for a_2.)	a1x+b1y=c1 a2x → b2 ? 0.
4 EXE (Enter value for b_2.)	a1x+b1y=c1 a2x → c2 ? 0.

26 [EXE] (Enter value for c_2.)	a1χ+b1y=c1 a2χ → d= 0.
[EXE] (d is a dummy.)	a1χ+b1y=c1 a2χ → χ= 8.
[EXE]	a1χ+b1y=c1 a2χ → y= -3.5

3. Simultaneous Linear Equation with Three Unknowns

$$\begin{cases} a_1x + b_1y + c_1z = d_1 \\ a_2x + b_2y + c_2z = d_2 \\ a_3x + b_3y + c_3z = d_3 \end{cases} \qquad \begin{pmatrix} a_1b_2c_3 + b_1c_2a_3 + c_1b_3a_2 - c_1b_2a_3 \\ -b_1a_2c_3 - a_1b_3c_2 \neq 0 \end{pmatrix}$$

- The simultaneous linear equation with three unknowns can be solved when a_1, b_1, c_1, d_1, a_2, b_2, c_2, d_2, a_3, b_3, c_3 and d_3 are known.

Example

Solve: $\begin{cases} 4x+y-2z=-1 \\ x+6y+3z=1 \\ -5x+4y+z=-7 \end{cases}$

Operation	Display
[AC] 3 [FMLA] (Recall simultaneous linear equation with three unknowns.)	a1x+b1y+c1z=d1 a1 ? 0.
4 [EXE] (Enter value for a_1.)	a1x+b1y+c1z=d1 b1 ? 0.
1 [EXE] (Enter value for b_1.)	a1x+b1y+c1z=d1 c1 ? 0.
[(−)] 2 [EXE] (Enter value for c_1.)	a1x+b1y+c1z=d1 d1 ? 0.
[(−)] 1 [EXE] (Enter value for d_1.)	a1x+b1y+c1z=d1 a2 ? 0.
1 [EXE] (Enter value for a_2.)	a1x+b1y+c1z=d1 b2 ? 0.

6 [EXE] (Enter value for b_2.)	$a_1x+b_1y+c_1z=d_1$ c_2? 0.
3 [EXE] (Enter value for c_2.)	$a_1x+b_1y+c_1z=d_1$ d_2? 0.
1 [EXE] (Enter value for d_2.)	$a_1x+b_1y+c_1z=d_1$ a_3? 0.
[(−)] 5 [EXE] (Enter value for a_3.)	$a_1x+b_1y+c_1z=d_1$ b_3? 0.
4 [EXE] (Enter value for b_3.)	$a_1x+b_1y+c_1z=d_1$ c_3? 0.
1 [EXE] (Enter value for c_3.)	$a_1x+b_1y+c_1z=d_1$ d_3? 0.
[(−)] 7 [EXE] (Enter value for d_3.)	$a_1x+b_1y+c_1z=d_1$ Disp d= 0.
[EXE] (d is a dummy.)	$a_1x+b_1y+c_1z=d_1$ Disp x= 1.
[EXE]	$a_1x+b_1y+c_1z=d_1$ Disp y= −1.
[EXE]	$a_1x+b_1y+c_1z=d_1$ z= 2.

4. Cosine Theorem

$$a^2 = b^2 + c^2 - 2bc\cos\theta \rightarrow a = \sqrt{b^2 + c^2 - 2bc\cos\theta}$$

(b, $c > 0$, $0^\circ < \theta < 180^\circ$)

a, b and c are sides of a triangle. θ is adjoining angle.

- The cosine theorem is used when the lengths of two sides of a triangle and their adjoining angle are known to determine the length of the remaining side.

Example

Two sides of a triangle are $b = 15$cm and $c = 9.5$cm. The angle formed by these two sides is $\theta = 62.3$ degrees. Determine the length of the remaining side a.

Operation	Display
[MODE] [4] (Degree)	
[AC] 4 [FMLA] (Recall cosine theorem.)	a=√(b²+c²−2bc b? 0.
15 [EXE] (Enter value for b.)	a=√(b²+c²−2bc c? 0.
9.5 [EXE] (Enter value for c.)	a=√(b²+c²−2bc A? 0.
62.3 [EXE] (Enter value for θ.)	a=√(b²+c²−2bc a= 13.51924617

5. Heron's Formula

$$S=\sqrt{s(s-a)(s-b)(s-c)} \text{、} s=\frac{a+b+c}{2}$$

a, b and c are sides of a triangle. $\begin{pmatrix} a+b>c>0 \\ b+c>a>0 \\ c+a>b>0 \end{pmatrix}$

•Heron's formula is used to calculate the area of a triangle for which the lengths of its three sides are known.

Example

Determine the area of a triangle with the three sides $a=12$cm, $b=8$cm, $c=17$cm.

Operation	Display
AC 5 FMLA (Recall Heron's formula.)	S=√(s(s−a)(s−b a? 0.
12 EXE (Enter value for a.)	S=√(s(s−a)(s−b b? 0.
8 EXE (Enter value for b.)	S=√(s(s−a)(s−b c? 0.
17 EXE (Enter value for c.)	S=√(s(s−a)(s−b s= 18.5
EXE	S=√(s(s−a)(s−b S=43.51939223

6. Area of a Triangle

$$S = \frac{1}{2} bc \sin A \qquad (0° < A < 180°)$$

b and c are sides of a triangle. A is adjoining angle.

• This equation is used to calculate the area of a triangle when the lengths of two sides and their adjoining angle are known.

Example

Determine the area of a triangle when two sides measure $b = 15$cm and $c = 9.5$cm, with the adjoining angle to the two sides being $A = 62.3$ degrees.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 6 [FMLA] (Recall area of a triangle.)	S=bcsin A/2 b? 0.
15 [EXE] (Enter value for b.)	S=bcsin A/2 c? 0.
9.5 [EXE] (Enter value for c.)	S=bcsin A/2 A? 0.
62.3 [EXE] (Enter value for A.)	S=bcsin A/2 S=63.08429584

7. Sine Theorem (1)

$$\frac{a}{\sin A} = 2R \qquad \left(\begin{array}{l} 0° < A < 180° \\ a > 0,\ R > 0 \end{array}\right)$$

a is one side of a triangle, A is its opposite angle, R is a radius of circumscribed circle

- This calculator is programmed with the following three formulas.

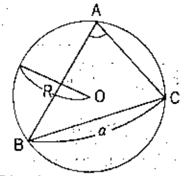
① $a = 2R \cdot \sin A$ This formula uses the sine theorem to calculate the length of the side opposite a known angle.

② $R = a / \sin A$ This formula calculates the radius of a circle that circumscribes a triangle for which the length of one side and the angle opposite the side are known.

③ $A = \sin^{-1}(a/2R)$ This formula calculates the angle of a triangle for which the length of the side opposite the angle and the radius of a circle that circumscribes the triangle are known. With this formula, the calculated range of A is: $0° < A \leqq 90°$.

The formulas are stored in the sequence noted above. If you press [EXE] while the result of formula ① or ② is displayed (while the [Disp] indicator is on the display), the next sequential formula is executed. Pressing [EXE] while the result of formula ③ is displayed executes formula ①.

Example



Triangle ABC is inscribed within a circle with a radius of R = 4.5mm. Angle A is 40°. Calculate the length of the side opposite A. Also calculate what the length of radius R would become if side a of triangle ABC were 5cm and its opposite angle A is 60°.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 7 [FMLA] (Recall sine theorem formula ①.)	a/sin A=2R R? 0.
4.5 [EXE] (Enter value for R.)	a/sin A=2R A? 0.
40 [EXE] (Enter value for A.)	a/sin A=2R Disp a= 5.785088487
[EXE] (Execute next formula.)	a/sin A=2R a? 5.785088487
5 [EXE] (Enter value for a.)	a/sin A=2R A? 40.
60 [EXE] (Enter value for A.)	a/sin A=2R Disp R= 2.886751346

- To restart execution from formula ①, press [AC] followed by [FMLA]. Note, however, that this operation also clears any values you input previously.

8. Sine Theorem (2)

$$\frac{a}{\sin A}=\frac{b}{\sin B}=\frac{c}{\sin C}=2R \qquad \left(\begin{matrix}0°<A, B, C<180° \\ a, b, c, R>0\end{matrix}\right)$$

- This sine theorem is used when the length of one side, its opposite angle, and another angle are known for a triangle to determine the lengths of the other two sides, the other two angles, and the radius of the circumscribed circle.

Example

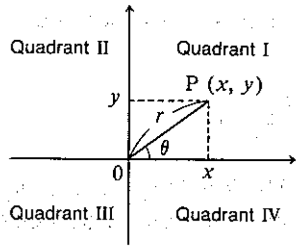
The length of one side is $b=7$cm, its opposite angle is $B=60$ degrees, and another angle is $A=40$ degrees. Determine the length of side a.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 8 [FMLA] (Recall sine theorem (2).)	a/sin A=b/sin → b? 0.
7 [EXE] (Enter value for b.)	a/sin A=b/sin → A? 0.
40 [EXE] (Enter value for A.)	a/sin A=b/sin → B? 0.
60 [EXE] (Enter value for B.)	a/sin A=b/sin → a=5.195590393

9. Rectangular → Polar Coordinate Conversion

$$r=\sqrt{x^2+y^2},\quad \theta=\tan^{-1}\frac{y}{x} \qquad (x>0,\ -90^\circ \leqq \theta \leqq 90^\circ)$$

•Rectangular to polar coordinate conversion is used when the location of the rectangular coordinates is known.



Important

Be sure to perform one of the following correction procedures on the calculated value of θ when $x<0$:

•If $y \geqq 0$ (Quadrant II), $\theta+180^\circ$

•If $y<0$ (Quadrant III), $\theta-180^\circ$

Also note that $x=0$ is undefined, and so such a result produces an error (Ma ERROR).

Example Convert the rectangular coordinates for point A ($x=6.2$, $y=2.0$) to polar coordinates r and θ.

Operation	Display
MODE 4 EXE (Degree)	
AC 9 FMLA (Recall rectangular to polar coordinate conversion.)	r=√(x2+y2) x? 0.
6.2 EXE (Enter value for x.)	r=√(x2+y2) y? 0.
2 EXE (Enter value for y.)	r=√(x2+y2) Disp r= 6.51459899
EXE	θ=tan-1(y/x) θ= 17.8786966

The following formula can also be used to calculate the value of θ in cases where it is irrelevant whether x is positive or negative.

$$\theta=\frac{y}{\text{Abs } y}\times\cos^{-1}\frac{x}{\sqrt{x^2+y^2}} \qquad (y\neq 0;\ -180^\circ<\theta<180^\circ \text{ and } \theta\neq 0)$$

10. Polar → Rectangular Coordinate Conversion

$x = r\cos\theta \qquad y = r\sin\theta \qquad (0 \leqq r)$

• Polar to rectangular coordinate conversion is used when the location of the polar coordinates is known.

Example

Convert the distance from the origin ($r=6.5$) and the angle from the x-axis ($\theta=18$ degrees) to rectangular coordinates for point A.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 1 0 [FMLA] (Recall polar to rectangular coordinate conversion.)	x=rcos θ r? 0.
6.5 [EXE] (Enter value for r.)	x=rcos θ θ? 0.
18 [EXE] (Enter value for θ.)	x=rcos θ x=6.181867356
[EXE]	y=rsin θ y=2.008610463

11. Logarithm with Random Base

$$\log_y x = \frac{\log bx}{\log by} \quad \left(\begin{array}{l} b>0 \quad b \neq 1 \quad 0<x,\ y \\ \text{here, } b=10 \end{array}\right)$$

- The logarithm with a random base is used in calculations in place of common logarithms (base 10).

Example

Determine $\log_5 3$ for $x=3$ when base $y=5$.

Operation	Display
AC 1 1 FMLA (Recall logarithm with random base.)	log yx=log x/1 x? 0.
3 EXE (Enter value for x.)	log yx=log x/1 y? 0.
5 EXE (Enter value for y.)	log yx=log x/1 L=0.682606194

12. Permutation

$$ {}_nP_r = \frac{n!}{(n-r)!} \qquad \left(\begin{array}{l} 0 \leqq r \leqq n \\ n, r \text{ are integers} \end{array} \right) $$

- Permutation is used to determine the total number of arrangements possible when r number of items are taken from a total of n items. With this calculator, the maximum value of n is 69.

Example

Determine the number of permutations possible when three items ($r=3$) are taken from a total of 10 items ($n=10$).

Operation	Display
AC 1 2 FMLA (Recall permutation.)	P=n!/(n−r)! n? 0.
1 0 EXE (Enter value for n.)	P=n!/(n−r)! r? 0.
3 EXE (Enter value for r.)	P=n!/(n−r)! P= 720.

13. Combination

$$_nC_r = \frac{n!}{r!(n-r)!} \quad \begin{pmatrix} 0 \leqq r \leqq n \\ n, r \text{ are integers} \end{pmatrix}$$

- Combination is used to determine the total number of combinations possible when r number of items are taken from a total of n items. With this calculator, the maximum value of n is 69.

Example

Determine the number of combinations of three items ($r=3$) are possible from a total of 10 items ($n=10$).

Operation	Display
AC 1 3 FMLA (Recall combination.)	C=n!/(r!x(n-r) n? 0.
1 0 EXE (Enter value for n.)	C=n!/(r!x(n-r) r? 0.
3 EXE (Enter value for r.)	C=n!/(r!x(n-r) C= 120.

14. Repeated Permutation

$$_n\Pi_r = n^r \qquad \text{(n, r are positive integers)}$$

- Repeated permutation is used to determine the total number of arrangements possible when r number of items are taken from a total of n items, and when repeated use of the same item is allowed.

Example

Determine the number of permutations possible when three items ($r = 3$) are taken from a total of 10 items ($n = 10$). Repeated use of the same item is allowed.

Operation	Display
AC 1 4 FMLA (Recall repeated permutation.)	Π=nxʸr / n? 0.
1 0 EXE (Enter value for n.)	Π=nxʸr / r? 0.
3 EXE (Enter value for r.)	Π=nxʸr / Π= 1000.

15. Repeated Combination

$$_{n}\mathrm{H}_{r} = \frac{(n+r-1)!}{r!(n-1)!} \quad \left(\begin{array}{l} 0 \leqq r \\ 1 \leqq n \\ n,\ r \text{ are integers} \end{array}\right)$$

• Repeated combination is used to determine the total number of combinations possible when r number of items are taken from a total of n items, and when repeat use of the same item is allowed. With this calculator, the maximum value of $n+r$ is 70.

Example

Determine the number of combinations of three items ($r=3$) are possible from a total of 10 items ($n=10$). Repeat use of the same item is allowed.

Operation	Display
AC 1 5 FMLA (Recall repeated combination.)	H=(n+r−1)!/(r! n? 0.
1 0 EXE (Enter value for n.)	H=(n+r−1)!/(r! r? 0.
3 EXE (Enter value for r.)	H=(n+r−1)!/(r! H= 220.

16. Sum of Arithmetic Progression

$$S=\frac{n\{2a+(n-1)d\}}{2}$$

- This equation is used to determine the sum from the initial term to the nth term when the initial term and common difference are known.

Example

Determine the sum up to $n=10$ for an arithmetic progression with an initial term of $a=1$ and a common difference of $d=2$.

Operation	Display
AC 1 6 FMLA (Recall sum of arithmetic progression.)	S=n(2a+(n−1)d) → n? 0.
1 0 EXE (Enter value for n.)	S=n(2a+(n−1)d) → a? 0.
1 EXE (Enter value for a.)	S=n(2a+(n−1)d) → d? 0.
2 EXE (Enter value for d.)	S=n(2a+(n−1)d) → S= 100.

17. Sum of Geometric Progression

$$S=\frac{a(r^n-1)}{r-1} \qquad (r \neq 1)$$

- This equation is used to determine the sum from the initial term to the nth term when the initial term and common ratio are known.

Example

Determine the sum up to $n=10$ for a geometric progression with an initial term of $a=1$ and a common ratio of $r=2$.

Operation	Display
AC 1 7 FMLA (Recall sum of geometric progression.)	S=a(rxʸn−1)/(r a? 0.
1 EXE (Enter value for a.)	S=a(rxʸn−1)/(r r? 0.
2 EXE (Enter value for r.)	S=a(rxʸn−1)/(r n? 0.
10 EXE (Enter value for n.)	S=a(rxʸn−1)/(r S= 1023.

18. Sum of Squares

$$S = 1^2 + 2^2 + \cdots\cdots + n^2 = \frac{1}{6}n(n+1)(2n+1)$$

(n is a positive integer)

• This equation is used to determine the sum of the squares of numbers from 1 to n.

Example

Determine the sum of squares from 1 to 10.

Operation	Display
AC 18 FMLA (Recall sum of squares.)	S=n(n+1)(2n+1) → n? 0.
10 EXE (Enter value for n.)	S=n(n+1)(2n+1) → S= 385.

19. Sum of Cubes

$$S = 1^3 + 2^3 + \cdots\cdots + n^3 = \left\{ \frac{n(n+1)}{2} \right\}^2$$

(n is a positive integer)

• This equation is used to determine the sum of the cubes of numbers from 1 to n.

Example

Determine the sum of cubes from 1 to 10.

Operation	Display
AC 1 9 FMLA (Recall sum of cubes.)	S=(n(n+1)/2)² n? 0.
1 0 EXE (Enter value for n.)	S=(n(n+1)/2)² S= 3025.

20. Inner Product

$$\vec{a} \cdot \vec{b} = a_1 b_1 + a_2 b_2$$

(a_1, a_2) (b_1, b_2) are elements of vectors $\vec{a}$ and $\vec{b}$.

- This equation is used to determine the scaler product (inner product) when the elements of two vectors are known.

Example

Find the inner product for the following two vectors:

$\vec{a} = (3, 14)$

$\vec{b} = (-7, 1)$

Operation	Display
AC 20 FMLA (Recall inner product.)	S=a1b1+a2b2 a1? 0.
3 EXE (Enter value for a_1.)	S=a1b1+a2b2 b1? 0.
(−) 7 EXE (Enter value for b_1.)	S=a1b1+a2b2 a2? 0.
14 EXE (Enter value for a_2.)	S=a1b1+a2b2 b2? 0.
1 EXE (Enter value for b_2.)	S=a1b1+a2b2 S= −7.

21. Angle Formed by Vector

$$\cos\theta = \frac{(\vec{a}, \vec{b})}{|\vec{a}||\vec{b}|} = \frac{a_1 b_1 + a_2 b_2}{\sqrt{a_1^2 + a_2^2}\sqrt{b_1^2 + b_2^2}} \qquad (a_1, a_2, b_1, b_2 \neq 0)$$

(a_1, a_2) (b_1, b_2) are elements of vectors $\vec{a}$ and $\vec{b}$.

- This equation is used when the elements of two vectors are known to determine the angle formed by the two vectors.

Example

Determine the angle formed by the following two vectors:

$\vec{a}$ $(-2, 5)$

$\vec{b}$ $(-3, 2)$

Operation	Display
MODE 4 EXE (Degree)	
AC 2 1 FMLA (Recall angle formed by vector.)	θ=cos⁻¹ ((a1b1+ a1 ? 0.
(−) 2 EXE (Enter value for a_1.)	θ=cos⁻¹ ((a1b1+ b1 ? 0.
(−) 3 EXE (Enter value for b_1.)	θ=cos⁻¹ ((a1b1+ a2 ? 0.
5 EXE (Enter value for a_2.)	θ=cos⁻¹ ((a1b1+ b2 ? 0.
2 EXE (Enter value for b_2.)	θ=cos⁻¹ ((a1b1+ θ =34.50852299

22. Distance Between Two Points

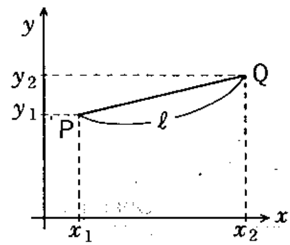
$$\ell = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

(x_1, y_1) (x_2, y_2) are coordinates of a point.

- This equation is used to determine the distance between two points when the x, y-coordinates of the points are known.

Example

Determine the distance between points P = (3, 6) and Q = (7, 12).



Operation	Display
AC 22 FMLA (Recall distance between two points.)	l=√((χ2−χ1)2+(χ2? 0.
7 EXE (Enter value for x_2.)	l=√((χ2−χ1)2+(χ1? 0.
3 EXE (Enter value for x_1.)	l=√((χ2−χ1)2+(y2? 0.
12 EXE (Enter value for y_2.)	l=√((χ2−χ1)2+(y1? 0.
6 EXE (Enter value for y_1.)	l=√((χ2−χ1)2+(l= 7.211102551

23. Distance Between Point and Straight Line

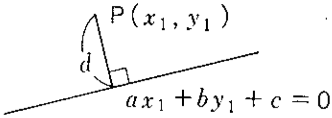
$$d = \frac{|ax_1 + by_1 + c|}{\sqrt{a^2 + b^2}} \qquad (a, b \neq 0)$$

(x_1, y_1) are coordinates of a point; a, b and c are constants.

- This equation is used to determine the distance between a point and a straight line when the x, y- coordinates of the point and the equation for the straight line are known.

Example

Determine the distance between point P (3, 5) and straight line $2x+5y+1=0$.



Operation	Display
AC 23 FMLA (Recall distance between point and straight line.)	d=Abs (ax1+by1 / a? 0.
2 EXE (Enter value for a.)	d=Abs (ax1+by1 / x1? 0.
3 EXE (Enter value for x_1.)	d=Abs (ax1+by1 / b? 0.
5 EXE (Enter value for b.)	d=Abs (ax1+by1 / y1? 0.
5 EXE (Enter value for y_1.)	d=Abs (ax1+by1 / c? 0.
1 EXE (Enter value for c.)	d=Abs (ax1+by1 / d= 5.942250822

24. Angle of Intersect for Two Straight Lines

$$\tan\theta = \frac{m_2 - m_1}{1 + m_1 m_2} \qquad (m_1 m_2 \neq 1)$$

m_1, m_2 are slopes of lines.

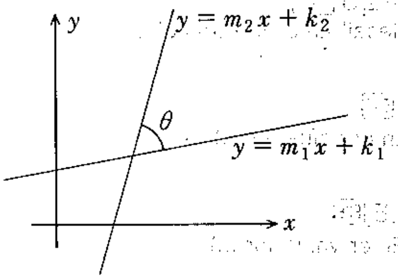
- This equation is used to determine the angle of intersect for two straight lines when their slopes are known.

Example

Determine the angle of intersect θ for the following two straight lines.

$y = 2x - 13$

$y = 0.5x + 2$



Operation	Display
MODE 4 EXE (Degree)	
AC 24 FMLA (Recall angle of intersect for two straight lines.)	θ=tan⁻¹ ((m2−m1 → / m2? 0.
2 EXE (Enter value for m_2.)	θ=tan⁻¹ ((m2−m1 → / m1? 0.
0.5 EXE (Enter value for m_1.)	θ=tan⁻¹ ((m2−m1 → / θ=36.86989765

25. Area of a Triangle

$$S = \frac{1}{2}ah \qquad (a, h \geqq 0)$$

a is base of triangle, h is height of triangle

- This equation is used to determine the area of a triangle when the length of the base and the height of the triangle are known.

Example

Determine the area of a triangle with a base of $a = 9$cm and a height of $h = 6.5$cm.

Operation	Display
AC 25 FMLA (Recall area of a triangle.)	S=ah/2 a? 0.
9 EXE (Enter value for a.)	S=ah/2 h? 0.
6.5 EXE (Enter value for h.)	S=ah/2 S= 29.25

26. Area of a Rectangle

$S = ab \qquad (a, b \geqq 0)$

a and b are sides of a rectangle.

- This equation is used to determine the area of a rectangle when the lengths of its sides are known.

Example

Determine the area of a rectangle that is $a = 8$cm by $b = 17$cm.

Operation	Display
AC 26 FMLA (Recall area of a rectangle.)	S=ab a? 0.
8 EXE (Enter value for a.)	S=ab b? 0.
17 EXE (Enter value for b.)	S=ab S= 136.

27. Area of a Parallelogram (1)

$S = ah \qquad (a、h \geqq 0)$

a is the base, h is the height

- This equation is used to determine the area of a parallelogram when the length of the base and the height are known.

Example

Determine the area of a parallelogram with a base of $a = 9.2$cm and a height of $h = 4.5$cm.

Operation	Display
AC 27 FMLA (Recall area of a parallelogram (1).)	S=ah a? 0.
9.2 EXE (Enter value for a.)	S=ah h? 0.
4.5 EXE (Enter value for h.)	S=ah S= 41.4

28. Area of a Parallelogram (2)

$$S = ab \sin \alpha \quad \left(\begin{matrix} a、b \geqq 0 \\ 0° < \alpha < 180° \end{matrix} \right)$$

a and b are sides, α is adjoining angle

- This equation is used to determine the area of a parallelogram when the length of two sides and their adjoining angle are known.

Example

Two sides of a parallelogram are $a = 7$cm and $b = 12$cm. The angle formed by these two sides is $\alpha = 36$ degrees. Determine the area of the parallelogram.

Operation	Display
MODE 4 EXE (Degree)	
AC 28 FMLA (Recall area of a parallelogram (2).)	S=absin α a? 0.
7 EXE (Enter value for a.)	S=absin α b? 0.
1 2 EXE (Enter value for b.)	S=absin α α? 0.
36 EXE (Enter value for α.)	S=absin α S=49.37396119

29. Area of a Trapezoid

$$S = \frac{1}{2}(a+b)h \qquad (a, b, h \geqq 0)$$

a is upper side, b is base, h is height

- This equation is used to determine the area of a trapezoid when the upper side, base, and height are known.

Example

Determine the area of a trapezoid with an upper side of $a=7$cm, a base of $b=13$cm and a height of $h=3.6$cm.

Operation	Display
AC 2 9 FMLA (Recall area of a trapezoid.)	S=(a+b)h/2 a? 0.
7 EXE (Enter value for a.)	S=(a+b)h/2 b? 0.
1 3 EXE (Enter value for b.)	S=(a+b)h/2 h? 0.
3.6 EXE (Enter value for h.)	S=(a+b)h/2 S= 36.

30. Area of a Circle

$S = \pi r^2 \qquad (r \geqq 0)$

r is radius

•This equation is used to determine the area of a circle when the radius is known.

Example

Determine the area of a circle with a radius of $r=11.5$cm.

Operation	Display
AC 30 FMLA (Recall area of a circle.)	S=πr2 r? 0.
11.5 EXE (Enter value for r.)	S=πr2 S=415.4756284

31. Area of a Sector (1)

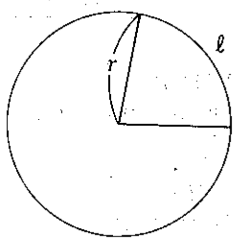
$$S = \frac{1}{2} r\ell \qquad (r,\ \ell \geqq 0)$$

r is radius, ℓ is length of arc

• This equation is used to determine the area of a sector when its radius and arc are known.

Example

Determine the area of a sector with a radius of r=5cm and an arc of ℓ=7cm.



Operation	Display
AC 3 1 FMLA (Recall area of a sector (1).)	S=rl/2 r ? 0.
5 EXE (Enter value for r.)	S=rl/2 l ? 0.
7 EXE (Enter value for ℓ.)	S=rl/2 S= 17.5

32. Area of a Sector (2)

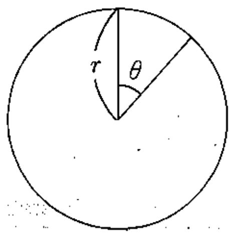
$$S = \frac{\pi r^2 \theta}{360} \qquad \left(\begin{array}{l} r \geqq 0 \\ 0° \leqq \theta \leqq 360° \end{array} \right)$$

r is radius, θ is central angle

- This equation is used to determine the area of a sector when its radius and central angle are known.

Example

Determine the area of a sector with a radius of r=6cm and a central angle of θ=42 degrees.



Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 32 [FMLA] (Recall area of a sector (2).)	S=πr²θ/360 r? 0.
6 [EXE] (Enter value for r.)	S=πr²θ/360 θ? 0.
42 [EXE] (Enter value for θ.)	S=πr²θ/360 S= 13.19468915

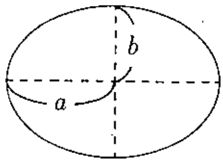
33. Area of an Ellipse

$$S = \pi ab \qquad (a、b \geqq 0)$$

- This equation is used to determine the area of an ellipse when its major and minor radii are known.

Example

Determine the area of an ellipse with a major radius of $a = 24$cm and a minor radius of $b = 17$cm.



Operation	Display
AC 33 FMLA (Recall area of an ellipse.)	S=πab a? 0.
24 EXE (Enter value for a.)	S=πab b? 0.
17 EXE (Enter value for b.)	S=πab S= 1281.769803

34. Volume of a Sphere

$$V=\frac{4}{3}\pi r^3 \qquad (r \geqq 0)$$

r is radius

- This equation is used to determine the volume of a sphere when its radius is known.

Example

Determine the volume of a sphere with a radius of $r=8$cm.

Operation	Display
AC 34 FMLA (Recall volume of a sphere.)	V=4πr³/3 r? 0.
8 EXE (Enter value for r.)	V=4πr³/3 V=2144.660585

35. Surface Area of a Sphere

$$S = 4\pi r^2 \qquad (r \geqq 0)$$

r is radius

• This equation is used to determine the surface area of a sphere when its radius is known.

Example

Determine the surface area of a sphere with a radius of $r = 5$cm.

Operation	Display
AC 3 5 FMLA (Recall surface area of a sphere.)	S=4πr2 r? 0.
5 EXE (Enter value for r.)	S=4πr2 S=314.1592654

36. Volume of a Circular Cylinder

$$V = \pi r^2 h \qquad (r,\ h \geqq 0)$$

r is radius of base, h is height

- This equation is used to determine the volume of a circular cylinder when the radius of its base and its height are known.

Example

Determine the volume of a circular cylinder with a height of $h = 14$cm and a base of radius $r = 6$cm.

Operation	Display
AC 36 FMLA (Recall volume of a circular cylinder.)	V=πr²h r? 0.
6 EXE (Enter value for r.)	V=πr²h h? 0.
14 EXE (Enter value for h.)	V=πr²h V= 1583.362697

37. Lateral Area of a Circular Cylinder

$S_0 = 2\pi rh \qquad (r, h \geqq 0)$

r is radius of base, h is height

- This equation is used to determine the lateral area of a circular cylinder when the radius of its base and its height are known.

Example

Determine the lateral area of a circular cylinder with a height of $h = 14$cm and a base of radius $r = 6$cm.

Operation	Display
AC 37 FMLA (Recall lateral area of a circular cylinder.)	S0=2πrh r ? 0.
6 EXE (Enter value for r.)	S0=2πrh h ? 0.
14 EXE (Enter value for h.)	S0=2πrh S0 = 527.7875658

38. Volume of a Pyramid

$$V=\frac{1}{3}Ah \qquad (A, h \geqq 0)$$

A is area of base, h is height

- This equation is used to determine the volume of a pyramid when its height and the area of its base are known.

Example

Determine the volume of a pyramid with a height of $h=7$cm and a base of area $A=56$cm^2.

Operation	Display
AC 38 FMLA (Recall volume of a pyramid.)	V=Ah/3 A? 0.
56 EXE (Enter value for A.)	V=Ah/3 h? 0.
7 EXE (Enter value for h.)	V=Ah/3 V= 130.6666667

39. Volume of a Circular Cone

$$V = \frac{1}{3}\pi r^2 h \qquad (r, h \geqq 0)$$

r is radius of base, h is height

• This equation is used to determine the volume of a circular cone when the radius of its base and its height are known.

Example

Determine the volume of a circular cone with a height of h = 9cm and a base of radius r = 2cm.

Operation	Display
AC 39 FMLA (Recall volume of a circular cone.)	V=πr²h/3 r? 0.
2 EXE (Enter value for r.)	V=πr²h/3 h? 0.
9 EXE (Enter value for h.)	V=πr²h/3 V= 37.69911184

40. Lateral Area of a Circular Cone

$S_0 = \pi r \ell \qquad (r,\ \ell \geqq 0)$

r is radius of base, ℓ is generatrix

- This equation is used to determine the lateral area of a circular cone when the radius of its base and its generatrix are known.

Example

Determine the lateral area of a circular cone with a generatrix of $\ell = 6$cm and a base of radius $r = 3$cm.

Operation	Display
AC 40 FMLA (Recall lateral area of a circular cone.)	S0=πrl r? 0.
3 EXE (Enter value for r.)	S0=πrl l? 0.
6 EXE (Enter value for ℓ.)	S0=πrl S0=56.54866776

41. Acceleration

$$a = \frac{v_2 - v_1}{t_2 - t_1} \qquad (t_2 > t_1 \geqq 0)$$

v_2 is velocity for time t_2, v_1 is velocity for time t_1

- This equation is used to determine the average acceleration between two points in time when the velocities are known for the two different points in time.

Example

Determine the average acceleration when the speed is $v_1 = 64$ km/h at $t_1 = 2{:}00$, and $v_2 = 72$ km/h at $t_2 = 2{:}15$.

Operation	Display
AC 4 1 FMLA (Recall acceleration.)	a=(V2−V1)/(t2− V2 ? 0.
72 EXE (Enter value for v_2.)	a=(V2−V1)/(t2− V1 ? 0.
64 EXE (Enter value for v_1.)	a=(V2−V1)/(t2− t2 ? 0.
2.25 EXE (Enter value for t_2. Here 2:15 is entered as 2.25.)	a=(V2−V1)/(t2− t1 ? 0.
2 EXE (Enter value for t_1.)	a=(V2−V1)/(t2− a= 32.

42. Distance of Advance

$$S = v_0 t + \frac{1}{2} a t^2 \qquad (t \geqq 0)$$

v_0 is initial velocity, a is acceleration and t is time

- This equation is used to determine the distance advanced in t seconds when the initial velocity and acceleration are known.

Example

Determine the distance advanced by a mass in $t = 5$ seconds when the initial velocity is $v_0 = 12$ cm/s and the acceleration is $a = 3\text{cm/s}^2$.

Operation	Display
AC 42 FMLA (Recall distance of advance.)	S=v0 t+at2/2 v0 ? 0.
12 EXE (Enter value for v_0.)	S=v0 t+at2/2 t ? 0.
5 EXE (Enter value for t.)	S=v0 t+at2/2 a ? 0.
3 EXE (Enter value for a.)	S=v0 t+at2/2 S= 97.5

43. Distance of Drop

$$S = v_0 t + \frac{1}{2} g t^2 \qquad (t \geqq 0)$$

v_0 is initial velocity, g is gravitational acceleration

- This equation is used to determine the distance of drop in t seconds when the initial velocity is known.

Example

Determine the distance of drop in $t=4$ seconds when the initial velocity is $v_0=26$m/s.

Operation	Display
AC 43 FMLA (Recall distance of drop.)	S=V0t+gt2/2 V0? 0.
26 EXE (Enter value for v_0.)	S=V0t+gt2/2 t? 0.
4 EXE (Enter value for t.)	S=V0t+gt2/2 S= 182.4532

44. Law of Universal Gravitation

$$F = G\frac{Mm}{r^2} \qquad (M, m, r > 0)$$

M and m are mass, r is distance between two objects, G is universal gravitation constant

- This equation is used to determine the universal gravitation acting between two objects when the mass of each object and the distance between the two objects are known.

Example

Determine the universal gravitation acting between two objects of masses M = 12kg and m = 8kg, when the distance between the masses is r = 6m.

Operation	Display
AC 44 FMLA (Recall law of universal gravitation.)	F=GMm/r 2 M? 0.
12 EXE (Enter value for M.)	F=GMm/r 2 m? 0.
8 EXE (Enter value for m.)	F=GMm/r 2 r? 0.
6 EXE (Enter value for r.)	F=GMm/r 2 F= 1.7792 -10

45. Cycle of Circular Motion (1)

$$T = \frac{2\pi}{\omega} \qquad (\omega \neq 0)$$

ω is angular velocity

- This equation is used to determine the cycle of circular motion when the angular velocity is known.

Example

Determine the cycle of circular motion for movement at an angular velocity of $\omega = 2$ radians/s.

Operation	Display
AC 4 5 FMLA (Recall cycle of circular motion (1).)	T=2π/ω ω?
2 EXE (Enter value for ω.)	T=2π/ω T=3.141592654

46. Cycle of Circular Motion (2)

$$T = \frac{2\pi r}{v} \qquad (v \neq 0)$$

r is radius of circular motion, v is velocity of motion

This equation is used to determine the cycle of circular motion when the radius and velocity of the motion are known.

Example

Determine the cycle of circular motion for movement around a radius of $r = 12$cm and a velocity of $v = 4$cm/s.

Operation	Display
AC 46 FMLA (Recall cycle of circular motion (2).)	T=2πr/V r? 0.
12 EXE (Enter value for r.)	T=2πr/V V? 0.
4 EXE (Enter value for v.)	T=2πr/V T= 18.84955592

47. Cycle of Circular Motion (3)

$$T = \frac{1}{f} \qquad (f > 0)$$

f is frequency

- This equation is used to determine the cycle of circular motion when the frequency of the motion is known.

Example

Determine the cycle of circular motion when its frequency is $f = 13$.

Operation	Display
AC 4 7 FMLA (Recall cycle of circular motion (3).)	T=1/f f ? 0.
1 3 EXE (Enter value for f.)	T=1/f T= 0.076923076

48. Simple Harmonic Motion (1)

$x = r \sin \theta \qquad (r > 0)$

r is amplitude, θ is phase

- This equation is used to determine the displacement when the oscillation amplitude and phase are known.

Example

Determine the displacement for an amplitude of $r = 4.2$cm and a phase of $\theta = 30$ degrees.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 48 [FMLA] (Recall simple harmonic motion (1).)	x=rsin θ r? 0.
4.2 [EXE] (Enter value for r.)	x=rsin θ θ? 0.
30 [EXE] (Enter value for θ.)	x=rsin θ x= 2.1

49. Simple Harmonic Motion (2)

$$x = r \sin \omega t \qquad (r > 0)$$

r is amplitude, ω is angular velocity, t is time

- This equation is used to determine the displacement when the amplitude of simple harmonic motion, time and angular velocity are known.

Example

Determine the displacement for a simple harmonic motion with an amplitude of $r = 5$cm, time $t = 3$s and an angular velocity of $\omega = 30$ radians/s.

Operation	Display
MODE 5 EXE (Radian)	
AC 49 FMLA (Recall simple harmonic motion (2).)	x=rsin ωt r? 0.
5 EXE (Enter value for r.)	x=rsin ωt ω? 0.
30 EXE (Enter value for ω.)	x=rsin ωt t? 0.
3 EXE (Enter value for t.)	x=rsin ωt x= 4.469983319

50. Cycle of Spring Pendulum

$$T = 2\pi\sqrt{\frac{m}{k}} \qquad (m>0,\ k>0)$$

m is mass, k is spring constant

•This equation is used to determine the simple oscillation cycle when the mass of the weight and the spring constant are known.

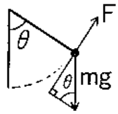
Example

Determine the simple oscillation cycle for a spring with a constant of $k=3.6$ N/m with a weight of mass $m=12$kg attached to its end.

Operation	Display
AC 50 FMLA (Recall cycle of spring pendulum.)	T=2π√(m/k) m? 0.
12 EXE (Enter value for m.)	T=2π√(m/k) k? 0.
3.6 EXE (Enter value for k.)	T=2π√(m/k) T= 11.47147442

51. Simple Pendulum (1)

$F = -mg \sin\theta \qquad (m>0)$



m is mass of weight, θ is the angle of deflection from perpendicular, g is gravitational acceleration

- This equation is used to determine the movement force of a weight when its mass and the angle of deflection θ are known.

Example

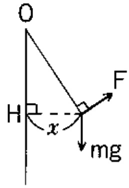
Determine the movement force of a weight with a mass of $m = 34$kg forming a simple pendulum with an angle of deflection of $\theta = 48$ degrees.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 5 1 [FMLA] (Recall simple pendulum (1).)	F=-mgsin θ / m? 0.
34 [EXE] (Enter value for m.)	F=-mgsin θ / θ? 0.
48 [EXE] (Enter value for θ.)	F=-mgsin θ / F=-247.7838809

52. Simple Pendulum (2)

$$F = -\frac{mg}{\ell}x \qquad \begin{pmatrix} \ell > 0 \\ m > 0 \end{pmatrix}$$

m is mass of weight, ℓ is length of string, x is location of weight, g is gravitational acceleration



• This equation is used to determine the movement force of a weight when its mass, the length of the string, and the position of the mass are known.

Example

Determine the movement force of a weight with a mass of $m = 28$kg forming a simple pendulum with a string of length $\ell = 1.5$m, when the weight is at position $x = 1.2$m.

Operation	Display
AC 52 FMLA (Recall simple pendulum (2).)	F=-mgx/l m? 0.
28 EXE (Enter value for m.)	F=-mgx/l x? 0.
1.2 EXE (Enter value for x.)	F=-mgx/l l? 0.
1.5 EXE (Enter value for ℓ.)	F=-mgx/l F= -219.66896

53. Cycle of Simple Pendulum

$$T = 2\pi\sqrt{\frac{\ell}{g}} \qquad (\ell > 0)$$

ℓ is length of string, g is gravitational acceleration

- This equation is used to determine the cycle of a simple pendulum when the length of the string is known.

Example

Determine the cycle of a simple pendulum with a string $\ell = 1.8$ meters long.

Operation	Display
AC 53 FMLA (Recall cycle of simple pendulum.)	T=2π√(l/g) l ? 0.
1.8 EXE (Enter value for ℓ.)	T=2π√(l/g) T= 2.691880541

54. Centrifugal Force (1)

$$F = mr\omega^2 \qquad (m, r, \omega > 0)$$

m is mass, r is radius, ω is angular velocity

• This equation is used to determine the centrifugal force for an object moving in a circular pattern when the mass, radius and angular velocity are known.

Example

Determine the centrifugal force for an object with a mass of $m = 4.2$kg, moving at an angular velocity of $\omega = 0.8$ radians/s, in a circular pattern with a radius of $r = 1.6$m.

Operation	Display
AC 54 FMLA (Recall centrifugal force (1).)	F=mrω2 m? 0.
4.2 EXE (Enter value for m.)	F=mrω2 r? 0.
1.6 EXE (Enter value for r.)	F=mrω2 ω? 0.
0.8 EXE (Enter value for ω.)	F=mrω2 F= 4.3008

55. Centrifugal Force (2)

$$F = m\frac{v^2}{r} \qquad (r,\ m,\ v>0)$$

m is mass, v is velocity, r is radius

• This equation is used to determine the centrifugal force for an object moving in a circular pattern when the mass, radius and velocity are known.

Example

Determine the centrifugal force for an object with a mass of $m=60$kg, moving at a velocity of $v=1.4$m/s, in a circular pattern with a radius of $r=3$m.

Operation	Display
AC 55 FMLA (Recall centrifugal force (2).)	F=mv2/r m? 0.
60 EXE (Enter value for m.)	F=mv2/r v? 0.
1.4 EXE (Enter value for v.)	F=mv2/r r? 0.
3 EXE (Enter value for r.)	F=mv2/r F= 39.2

56. Potential Energy

$$U_P = mgh \qquad (m, h > 0)$$

m is mass, h is height, g is gravitational acceleration.

- This equation is used to determine the potential energy for an object when its mass and height (potential) are known.

Example

Determine the potential energy for an object with a mass of $m = 3$kg at a height (potential) of $h = 5$m from the ground.

Operation	Display
AC 56 FMLA (Recall potential energy.)	Up=mgh m? 0.
3 EXE (Enter value for m.)	Up=mgh h? 0.
5 EXE (Enter value for h.)	Up=mgh Up= 147.09975

57. Kinetic Energy

$$U_K = \frac{1}{2} m v^2 \qquad (m, v > 0)$$

m is mass, v is velocity

• This equation is used to determine the kinetic energy for an object when its mass and velocity are known.

Example

Determine the kinetic energy for an object with a mass of $m = 8$kg and a velocity of $v = 2$m/s.

Operation	Display
AC 57 FMLA (Recall kinetic energy.)	Uk =mv2/2 m? 0.
8 EXE (Enter value for m.)	Uk =mv2/2 v? 0.
2 EXE (Enter value for v.)	Uk =mv2/2 Uk = 16.

58. Elastic Energy

$$U_P = \frac{1}{2} kx^2 \qquad (k, x > 0)$$

k is elastic constant, x is elongated length

- This equation is used to determine the elastic energy for an object when the elastic constant and elongated length are known.

Example

Determine the elastic energy for an object with an elastic constant of $k = 1.8$ N/m and a elongated length of $x = 0.4$ meters.

Operation	Display
AC 58 FMLA (Recall elastic energy.)	UP=kx2/2 k? 0.
1.8 EXE (Enter value for k.)	UP=kx2/2 x? 0.
0.4 EXE (Enter value for x.)	UP=kx2/2 UP= 0.144

59. Energy of Rotational Body

$$E = \frac{1}{2} I\omega^2 \qquad (I、\omega > 0)$$

I is moment of inertia, ω is angular velocity

• This equation is used to determine the energy of a rotational body when its moment of inertia and angular velocity are known.

Example

Determine the energy of a rotational body with a moment of inertia of $I = 2.2$ kg•m^2 and an angular velocity of $\omega = 3.8$ radians/s.

Operation	Display
AC 59 FMLA (Recall energy of rotational body.)	E=Iω²/2 I ? 0.
2.2 EXE (Enter value for I.)	E=Iω²/2 ω ? 0.
3.8 EXE (Enter value for ω.)	E=Iω²/2 E= 15.884

60. Sound Intensity

$$I = \frac{P}{4\pi r^2} \qquad (r > 0)$$

P is output from sound source, r is distance from sound source.

- This equation is used to determine the sound intensity when the output and distance from the sound source are known.

Example

Determine the sound intensity for an output of $P = 2.5 \times 10^{-3}$W at a distance of $r = 2$m from the sound source.

Operation	Display
AC 60 FMLA (Recall sound intensity.)	I=P/4πr2 P? 0.
2.5 EXP (−) 3 EXE (Enter value for P.)	I=P/4πr2 r? 0.
2 EXE (Enter value for r.)	I=P/4πr2 I = 4.973591972^{-05}

61. Velocity of Wave Transmitted by a Chord

$$v = \sqrt{\frac{T}{\sigma}} \qquad (T, \sigma > 0)$$

T is tensile strength of chord, σ is linear density
(= mass per 1cm of chord)

- This equation is used to determine the velocity of a wave transmitted by a chord when the tensile strength of the chord and the mass per 1cm of chord are known.

Example

Determine the velocity of a wave transmitted by a chord with a tensile strength of T = 2.4 dyn and a linear density of σ = 2g/cm.

Operation	Display
AC 6 1 FMLA (Recall velocity of wave transmitted by a chord.)	V=√(T/σ) T? 0.
2.4 EXE (Enter value for T.)	V=√(T/σ) σ? 0.
2 EXE (Enter value for σ.)	V=√(T/σ) V= 1.095445115

62. Doppler Effect

$$f = f_0 \frac{v-u}{v-v_0} \qquad \left(v \neq v_0,\ f_0 > 0,\ \frac{v-u}{v-v_0} > 0 \right)$$

f_0 is oscillation frequency of sound source, v is acoustic velocity, u is speed of movement of observer, v_0 is speed of sound source

- This equation is used to determine the oscillation frequency of a sound heard by an observer moving in the same direction as the sound source when the source oscillation frequency and acoustic velocity, as well as the speeds of the sound source and observer are known.

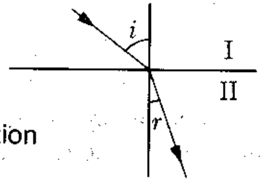
Example

Determine the oscillation frequency heard by an observer moving at a speed of $u = 8$m/s in the same direction as a sound source moving at a speed of $v_0 = 12$m/s. The oscillation frequency of the source is $f_0 = 522$Hz/s, and the acoustic velocity is $v = 340$m/s (15 degrees C air temperature).

Operation	Display
AC 62 FMLA (Recall doppler effect.)	f=f0(v−u)/(v−v → f0? 0.
522 EXE (Enter value for f_0.)	f=f0(v−u)/(v−v → v? 0.
340 EXE (Enter value for v.)	f=f0(v−u)/(v−v → u? 0.
8 EXE (Enter value for u.)	f=f0(v−u)/(v−v → v0? 0.
12 EXE (Enter value for v_0.)	f=f0(v−u)/(v−v → f= 528.3658537

63. Relative Index of Refraction

$$n = \frac{\sin i}{\sin r} \qquad (i,\ r > 0)$$



i is angle of incidence, r is angle of refraction

• This equation is used to determine the relative angle index of refraction for medium II relative to medium I when the angle of incidence and angle of refraction are known when a light enters medium II from medium I.

Example

Determine the relative index of refraction for an angle of incidence $i = 62$ degrees, and an angle of refraction $r = 48$ degrees.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 63 [FMLA] (Recall relative index of refraction.)	n=sin i/sin r i ? 0.
62 [EXE] (Enter value for i.)	n=sin i/sin r r ? 0.
48 [EXE] (Enter value for r.)	n=sin i/sin r n= 1.188123179

64. Critical Angle of Incidence

$$\sin ic = \frac{1}{n_{12}} \qquad (1 \leqq n_{12})$$

n_{12} is relative index of refraction of medium II relative to I

- This equation is used to determine the critical angle of incidence at which refracted rays cease to exist (becoming total reflection) when the relative index of refraction of medium II relative to I is known.

Example

Determine the critical angle of incidence when the relative index of refraction is $n = 1.33$.

Operation	Display
MODE 4 EXE (Degree)	
AC 64 FMLA (Recall critical angle of incidence.)	ic=sin⁻¹ (1/n) n? 0.
1.33 EXE (Enter value for n.)	ic=sin⁻¹ (1/n) ic= 48.75346663

65. Equation of State of Ideal Gas (1)

$$P=\frac{nRT}{V} \qquad (n、T、V>0)$$

n is number of mols, T is absolute temperature, V is volume, R is gas constant

- This equation is used to determine pressure for a gas when its number of mols, absolute temperature and volume are known.

Example

Determine the pressure of a $n=3$ mol gas with an absolute temperature of $T=280$K and a volume of $V=5\text{m}^3$.

Operation	Display
AC 65 FMLA (Recall equation of state of ideal gas (1).)	P=nRT/V n? 0.
3 EXE (Enter value for n.)	P=nRT/V T? 0.
280 EXE (Enter value for T.)	P=nRT/V V? 0.
5 EXE (Enter value for V.)	P=nRT/V P= 1396.82088

66. Equation of State of Ideal Gas (2)

$$V = \frac{nRT}{P} \qquad (n, T, P > 0)$$

n is number of mols, T is absolute temperature, P is pressure, R is gas constant

- This equation is used to determine volume for a gas when its number of mols, absolute temperature and pressure are known.

Example

Determine the volume of a $n = 2$ mol gas with an absolute temperature of T = 242K and a pressure of P = 30 N/m^2.

Operation	Display
AC 66 FMLA (Recall equation of state of ideal gas (2).)	V=nRT/P n? 0.
2 EXE (Enter value for n.)	V=nRT/P T? 0.
242 EXE (Enter value for T.)	V=nRT/P P? 0.
30 EXE (Enter value for P.)	V=nRT/P V= 134.139148

67. Equation of State of Ideal Gas (3)

$$T = \frac{PV}{nR} \qquad (P, V, n > 0)$$

n is number of mols, P is pressure, V is volume, R is gas constant

- This equation is used to determine absolute temperature for a gas when its number of mols, pressure, and volume are known.

Example

Determine the absolute temperature of a $n=3$ mol gas with a pressure of $P=24$ N/m^2 and volume of $V=8$ m^3.

Operation	Display
AC 67 FMLA (Recall equation of state of ideal gas (3).)	T=PV/nR P? 0.
24 EXE (Enter value for P.)	T=PV/nR V? 0.
8 EXE (Enter value for V.)	T=PV/nR n? 0.
3 EXE (Enter value for n.)	T=PV/nR T= 7.697479436

68. Equation of State of Ideal Gas (4)

$$n = \frac{PV}{RT} \qquad (P、V、T > 0)$$

P is pressure, V is volume, T is absolute temperature,
R is gas constant

• This equation is used to determine the number of mols for a gas when its pressure, volume, and absolute temperature are known.

Example

Determine the number of mols of a gas with a pressure of $P = 32$ N/m^2, a volume of $V = 6$ m^3, and an absolute temperature of $T = 246$K.

Operation	Display
AC 68 FMLA (Recall equation of state of ideal gas (4).)	n=PV/RT P? 0.
32 EXE (Enter value for P.)	n=PV/RT V? 0.
6 EXE (Enter value for V.)	n=PV/RT T? 0.
246 EXE (Enter value for T.)	n=PV/RT n= 0.0938717

69. Quantity of Heat

$Q = mcT$

m is mass, c is specific heat, T is temperature.

- This equation is used to determine the quantity of heat required to raise the temperature of an object T degrees C when the mass and specific heat of the object are known.

Example

Determine the quantity of heat required to raise wood with a mass of $m = 460$g and specific heat of $c = 0.6$cal/deg•g by $T = 10$ degrees C.

Operation	Display
AC 69 FMLA (Recall quantity of heat.)	Q=mcT m ? 0.
460 EXE (Enter value for m.)	Q=mcT c ? 0.
0.6 EXE (Enter value for c.)	Q=mcT T ? 0.
10 EXE (Enter value for T.)	Q=mcT Q = 2760.

70. Coulomb's Law

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

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
AC 70 FMLA (Recall Coulomb's law.)	F=(1/4πε0)×Qq/ Q? 0.
3 EXP (−) 5 EXE (Enter value for Q.)	F=(1/4πε0)×Qq/ q? 0.
2 EXP (−) 5 EXE (Enter value for q.)	F=(1/4πε0)×Qq/ r? 0.
0.5 EXE (Enter value for r.)	F=(1/4πε0)×Qq/ F=21.57012429

71. Magnetic Force

$$F = iB\ell \sin\theta \qquad (\ell > 0、0° \leq |\theta| \leq 90°)$$

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 $i = 4$A flows through a conductor of length $\ell = 1.2$m. The angle between the conductor and a uniform magnetic field with a magnetic flux density of B = 0.7T is $\theta = 30$ degrees.

Operation	Display
[MODE] [4] [EXE] (Degree)	
[AC] 7 1 [FMLA] (Recall magnetic force.)	F=iBlsin θ i ? 0.
4 [EXE] (Enter value for i.)	F=iBlsin θ B ? 0.
0.7 [EXE] (Enter value for B.)	F=iBlsin θ l ? 0.
1.2 [EXE] (Enter value for ℓ.)	F=iBlsin θ θ ? 0.
30 [EXE] (Enter value for θ.)	F=iBlsin θ F= 1.68

72. Resistance of a Conductor

$$R = \rho \frac{\ell}{S} \qquad (S、\ell、\rho > 0)$$

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 $\ell = 20$m and cross sectional area of $S = 1.6\text{mm}^2$ ($1.6 \times 10^{-6}\text{m}^2$). (The resistance of copper wire is $\rho = 1.72 \times 10^{-8}$ ohm•m.)

Operation	Display
AC 72 FMLA (Recall resistance of a conductor.)	R=ρl/S ρ?　　0.
1.72 EXP (−) 8 EXE (Enter value for ρ.)	R=ρl/S l?　　0.
20 EXE (Enter value for ℓ.)	R=ρl/S S?　　0.
1.6 EXP (−) 6 EXE (Enter value for S.)	R=ρl/S R=　　0.215

73. Frequency of Electric Oscillation

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

L is self-inductance, C is electric capacity

• 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 (millihenry), and an electric capacity of C=90pF.

Operation	Display
AC 73 FMLA (Recall frequency of electric oscillation.)	f=1/2π√(LC) L? 0.
60 EXP (−) 3 EXE (Enter value for L.)	f=1/2π√(LC) C? 0.
90 EXP (−) 12 EXE (Enter value for C.)	f=1/2π√(LC) f=68489.38267
ENG	f=1/2π√(LC) f=68.48938267^{03}

74. Average Gaseous Molecular Speed

$$v = \sqrt{\frac{3RT}{M}} \qquad (M, T > 0)$$

T is absolute temperature, M is molecular weight, R is gas constant

- This equation is used to determine average gaseous molecular speed for a gas when its temperature and molecular weight are known.

Example

Determine the average gaseous molecular speed for oxygen which has a molecular weight of $M = 32 \times 10^{-3}$ kg/mol and atmospheric temperature of 15 degrees C (absolute temperature $T = 288.2K$).

Operation	Display
AC 74 FMLA (Recall average gaseous molecular speed.)	V=√(3RT/M) T? 0.
288.2 EXE (Enter value for T.)	V=√(3RT/M) M? 0.
32 EXP (−) 3 EXE (Enter value for M.)	V=√(3RT/M) V= 473.9672617

75. Electronic Kinetic Energy in Magnetic Field

$$T=\frac{1}{2}mv^2=\frac{1}{2}\frac{q^2B^2}{m}R^2 \qquad (m>0,\ B>0,\ R>0)$$

T is kinetic energy, q is electron charge, B is magnetic flux density, m is electron mass, R is radius of circular motion

- This equation is used to determine the electronic kinetic energy when the radius of circular motion of the electrons determined by the magnetic flux density of the magnetic field is known.

Example

Determine the kinetic energy of electrons moving in a circle with a radius of $R=1.2\times10^{-1}$m, within a magnetic field with a magnetic flux density of $B=0.8$ Wb/m^2 (Wb = Weber).

Operation	Display
AC 75 FMLA (Recall electronic kinetic energy in magnetic field.)	T=q2B2R2/2m q? 0.
ALPHA CONST e EXE (Enter elementary charge.)	T=q2B2R2/2m B? 0.
0.8 EXE (Enter value for B.)	T=q2B2R2/2m R? 0.
1.2 EXP (−) 1 EXE (Enter value for R.)	T=q2B2R2/2m m? 0.
ALPHA CONST me EXE (Enter electron mass.)	T=q2B2R2/2m T=1.298505846^{-10}

76. Strength of Electric Field

$$E=\frac{Q}{4\pi\varepsilon_0 r^2}\left(=9\times10^9\frac{Q}{r^2}\right)\quad (r>0)$$

Q is quantity of electricity, r is distance from electric charge

• This equation is used to determine the strength of an electric field at a given distance from the electric charge when the quantity of the electricity is known.

Example

Determine the strength of an electric field at a point which is $r=20$cm distant from the electric charge when the quantity of the electricity is $Q=3\times10^{-7}$C.

Operation	Display
AC 76 FMLA (Recall strength of electric field.)	E=Q/4πε0 r2 Q? 0.
3 EXP (−) 7 EXE (Enter value for Q.)	E=Q/4πε0 r2 r? 0.
0.2 EXE (Enter value for r.)	E=Q/4πε0 r2 E= 67406.6384
ENG	E=Q/4πε0 r2 E= 67.4066384^{03}

77. Energy Density Stored in Electrostatic Field (1)

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

E is electric field, D is electric flux density

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

Example

Determine the energy density stored in an electrostatic field when the electric field with an electric flux density of $D = 8 \times 10^{-5}$ C/m^2 in an electric field of $E = 200$V/m.

Operation	Display
[AC] 7 7 [FMLA] (Recall energy density stored in electrostatic field (1).)	W=ED/2 E? 0.
2 0 0 [EXE] (Enter value for E.)	W=ED/2 D? 0.
8 [EXP] [(−)] 5 [EXE] (Enter value for D.)	W=ED/2 W= 8.$^{-03}$

78. Energy Density Stored in Electrostatic Field (2)

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

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 $\varepsilon = 6.2 \times 10^{-11}$ F/m within an electric field of E = 200 V/m.

Operation	Display
AC 78 FMLA (Recall energy density stored in electrostatic field (2).)	W=εE2/2 ε? 0.
6.2 EXP (−) 1 1 EXE (Enter value for ε.)	W=εE2/2 E? 0.
200 EXE (Enter value for E.)	W=εE2/2 W= 1.24^{-06}

79. Energy Stored in Electrostatic Capacity (1)

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

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
AC 79 FMLA (Recall energy stored in electrostatic capacity (1).)	W=CV2/2 C? 0.
6 EXP (−) 6 EXE (Enter value for C.)	W=CV2/2 V? 0.
700 EXE (Enter value for V.)	W=CV2/2 W= 1.47

80. Energy Stored in Electrostatic Capacity (2)

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

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 $Q = 4 \times 10^{-7}$C and electrostatic capacity of $C = 1.6\mu$F.

Operation	Display
AC 80 FMLA (Recall energy stored in electrostatic capacity (2).)	W=Q²/2C Q? 0.
4 EXP (-) 7 EXE (Enter value for Q.)	W=Q²/2C C? 0.
1.6 EXP (-) 6 EXE (Enter value for C.)	W=Q²/2C W= 5.$^{-08}$

81. Energy Stored in Electrostatic Capacity (3)

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

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 $V = 70$V.

Operation	Display
AC 8 1 FMLA (Recall energy stored in electrostatic capacity (3).)	W=QV/2 Q? 0.
1.2 EXP (−) 5 EXE (Enter value for Q.)	W=QV/2 V? 0.
70 EXE (Enter value for V.)	W=QV/2 W= 4.2^{-04}

82. 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
AC 82 FMLA (Recall force exerting on magnetic pole.)	F=mH m? 0.
2 EXE (Enter value for m.)	F=mH H? 0.
3 EXP (−) 3 EXE (Enter value for H.)	F=mH F= $6.^{-03}$

83. Magnetic Energy of Inductance

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

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
AC 83 FMLA (Recall magnetic energy of inductance.)	W=LI²/2 L? 0.
0.07 EXE (Enter value for L.)	W=LI²/2 I? 0.
6 EXE (Enter value for I.)	W=LI²/2 W= 1.26

84. Electrostatic Capacity between Parallel Plates

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

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).

Operation	Display
AC 84 FMLA (Recall electrostatic capacity between parallel plates.)	C=εS/d ε? 0.
2 ALPHA CONST ε₀ EXE (Enter value for ε.)	C=εS/d S? 0.
50 EXP (−) 4 EXE (Enter value for S.)	C=εS/d d? 0.
2 EXP (−) 2 EXE (Enter value for d.)	C=εS/d C= 4.427093909^{-12}

85. Impedance in LR Series Circuit

$Z = \sqrt{R^2 + (2\pi f L)^2} \quad (= \sqrt{R^2 + \omega^2 L^2}) \qquad (R, f, L > 0)$

R is resistance, f is frequency, L is inductance

- This equation is used to determine the impedance of an LR series circuit when the frequency, resistance and inductance are known.

Example

Determine the impedance for an LR series circuit with resistance of $R = 8$ ohms and inductance of $L = 0.05$H, for a frequency of $f = 50$Hz.

Operation	Display
AC 85 FMLA (Recall impedance in LR series circuit.)	Z=√(R²+(2πfL)² R? 0.
8 EXE (Enter value for R.)	Z=√(R²+(2πfL)² f? 0.
50 EXE (Enter value for f.)	Z=√(R²+(2πfL)² L? 0.
0.05 EXE (Enter value for L.)	Z=√(R²+(2πfL)² Z= 17.62782204

86. Impedance in RC Series Circuit

$$Z=\sqrt{R^2+\frac{1}{(2\pi fC)^2}}\ \left(=\sqrt{R^2+\frac{1}{\omega^2C^2}}\right)\qquad (R、f、C>0)$$

R is resistance, f is frequency, C is electric capacity

• This equation is used to determine the impedance of an RC series circuit of frequency f when the resistance and electric capacity are known.

Example

Determine the impedance for an RC series circuit with resistance of $R=12$ ohms and electric capacity of $C=30\mu F$ $(30\times10^{-6}F)$, for a frequency of $f=60Hz$.

Operation	Display
AC 86 FMLA (Recall impedance in RC series circuit.)	Z=√(R²+1/(2πfC R? 0.
12 EXE (Enter value for R.)	Z=√(R²+1/(2πfC f? 0.
60 EXE (Enter value for f.)	Z=√(R²+1/(2πfC C? 0.
30 EXP (−) 6 EXE (Enter value for C.)	Z=√(R²+1/(2πfC Z=89.22999812

87. Composite Reactance in LC Series Circuit

$$X = 2\pi f L - \frac{1}{2\pi f C} \quad \left(= \omega L - \frac{1}{\omega C} = X_L - X_C\right) \qquad (f, L, C > 0)$$

f is frequency, L is inductance, C is electric capacity

- This equation is used to determine the reactance of an LC series circuit of frequency f when the inductance and electric capacity are known.

Example

Determine the reactance for an LC series circuit with inductance of $L = 0.2$ H and electric capacity of $C = 70\mu F$ (70×10^{-6}F), for a frequency of $f = 50$Hz.

Operation	Display
AC 87 FMLA (Recall composite reactance in LC series circuit.)	X=2πfL−1/2πfC f ? 0.
50 EXE (Enter value for f.)	X=2πfL−1/2πfC L ? 0.
0.2 EXE (Enter value for L.)	X=2πfL−1/2πfC C ? 0.
70 EXP (−) 6 EXE (Enter value for C.)	X=2πfL−1/2πfC X= 17.35901219

88. Impedance in LRC Series Circuit

$$Z=\sqrt{R^2+\left(2\pi fL-\frac{1}{2\pi fC}\right)^2}\quad\left(=\sqrt{R^2+\left(\omega L-\frac{1}{\omega C}\right)}\right)$$

R is resistance, f is frequency, L is inductance, C is electric capacity $(R, f, L, C>0)$

•This equation is used to determine the impedance of an LRC series circuit of frequency f when the resistance, inductance, and electric capacity are known.

Example

Determine the impedance for an LRC series circuit with resistance of $R=2$ ohms, inductance of $L=0.08$H, and electric capacity of $C=30\mu$F $(30\times10^{-6}$F), for a frequency of $f=60$Hz.

Operation	Display
AC 88 FMLA (Recall impedance in LRC series circuit.)	Z=√(R²+(2πfL−1 R? 0.
2 EXE (Enter value for R.)	Z=√(R²+(2πfL−1 f? 0.
60 EXE (Enter value for f.)	Z=√(R²+(2πfL−1 L? 0.
0.08 EXE (Enter value for L.)	Z=√(R²+(2πfL−1 C? 0.
30 EXP (−) 6 EXE (Enter value for C.)	Z=√(R²+(2πfL−1 Z=58.29444204

89. Impedance in LRC Parallel Circuit

$$Z = \frac{1}{\sqrt{\left(\frac{1}{R}\right)^2 + \left(2\pi f C - \frac{1}{2\pi f L}\right)^2}} \qquad (R, f, C, L > 0)$$

R is resistance, f is frequency, L is inductance, C is electric capacity

• This equation is used to determine the impedance of an LRC parallel circuit of frequency f when the resistance, inductance, and electric capacity are known.

Example

Determine the impedance for an LRC parallel circuit with resistance of $R = 7$ ohms, inductance of $L = 0.05$H, and electric capacity of $C = 9\mu$F (9×10^{-6}F), for a frequency of $f = 60$Hz.

Operation	Display
AC 89 FMLA (Recall impedance in LRC parallel circuit.)	Z=1/√((1/R)²+(R? 0.
7 EXE (Enter value for R.)	Z=1/√((1/R)²+(f? 0.
60 EXE (Enter value for f.)	Z=1/√((1/R)²+(C? 0.
9 EXP (−) 6 EXE (Enter value for C.)	Z=1/√((1/R)²+(L? 0.
0.05 EXE (Enter value for L.)	Z=1/√((1/R)²+(Z=6.611918534

90. Series Resonance Circuit

$$Z_R = R,\ Z_X = 2\pi f L - \frac{1}{2\pi f C} \qquad (R, f, L, C, Z > 0)$$

R is resistance, f is frequency, L is inductance, C is electrostatic capacity, Z is impedance

- This equation is used to determine the impedance and the impedance of a series resonance circuit when the resistance, inductance, electrostatic capacity and frequency are known.

Example

Determine impedance Z_R and Z_X for resistance $R = 1$ ohm, electrostatic capacity $C = 15\mu F$ $(15 \times 10^{-6} F)$, coil inductance $L = 30mH$ $(30 \times 10^{-3} H)$, and frequency $f = 350Hz$.

Operation	Display
AC 90 FMLA (Recall series resonance circuit.)	ZR=R R? 0.
1 EXE (Enter value for R.)	ZR=R Disp ZR= 1.
EXE	Zx=2πfL−1/2πfC f? 0.
350 EXE (Enter value for f.)	Zx=2πfL−1/2πfC L? 0.
30 EXP (−) 3 EXE (Enter value for L.)	Zx=2πfL−1/2πfC C? 0.
15 EXP (−) 6 EXE (Enter value for C.)	Zx=2πfL−1/2πfC Zx= 35.65821847

91. Parallel Resonance Circuit

$$Y_R = 1/R,\ Y_X = 2\pi f C - \frac{1}{2\pi f L} \qquad (R, f, C, L > 0)$$

R is resistance, f is frequency, C is electrostatic capacity, L is inductance, Y is admittance

- This equation is used to determine the admittance (inverse of impedance) and the admittance of a parallel resonance circuit when the resistance, frequency, electrostatic capacity, and inductance are known.

Example

Determine admittance Y_R and Y_X for resistance $R = 200$ ohms, inductance $L = 50$mH (50×10^{-3}H), electrostatic capacity $C = 1\mu$F (1×10^{-6}F), and frequency $f = 1$kHz (1×10^{3}Hz).

Operation	Display
AC 91 FMLA (Recall parallel resonance circuit.)	YR=1/R R? 0.
200 EXE (Enter value for R.)	YR=1/R YR= 5.-03
EXE	Yx=2πfC−1/2πfL f? 0.
1 EXP 3 EXE (Enter value for f.)	Yx=2πfC−1/2πfL C? 0.
1 EXP (−) 6 EXE (Enter value for C.)	Yx=2πfC−1/2πfL L? 0.
50 EXP (−) 3 EXE (Enter value for L.)	Yx=2πfC−1/2πfL Yx= 3.100086445-03

92. Power Factor

$$\cos\varphi = \frac{R}{Z}\left(=\frac{P}{EI}\right) \qquad (R>0)$$

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
MODE 4 EXE (Degree)	
AC 92 FMLA (Recall power factor.)	Φ=COS⁻¹ (R/Z) R? 0.
12 EXE (Enter value for R.)	Φ=COS⁻¹ (R/Z) Z? 0.
16 EXE (Enter value for Z.)	Φ=COS⁻¹ (R/Z) Φ= 41.40962211

93. Joule's Law (1)

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

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
AC 93 FMLA (Recall Joule's law (1).)	P=RI 2 R? 0.
1.7 EXP (−) 4 EXE (Enter value for R.)	P=RI 2 I? 0.
20 EXE (Enter value for I.)	P=RI 2 P= 0.068

94. Joule's Law (2)

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

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
AC 94 FMLA (Recall Joule's law (2).)	P=V2/R V? 0.
100 EXE (Enter value for V.)	P=V2/R R? 0.
1.1 EXP (−) 2 EXE (Enter value for R.)	P=V2/R P= 909090.9091

95. Induced Electromotive Force

$V_e = vB\ell \qquad (v、B、\ell > 0)$

v is motive velocity of conductor, B is magnetic flux density, ℓ is length of conductor

- 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 $\ell = 1\text{m}$ when the conductor is moved through a magnetic field of $B = 0.2 \times 10^{-4} \frac{N}{Am}$ at a speed of $v = 12\text{m/s}$.

Operation	Display
AC 95 FMLA (Recall induced electromotive force.)	Ve=vBl v? 0.
12 EXE (Enter value for v.)	Ve=vBl B? 0.
0.2 EXP (−) 4 EXE (Enter value for B.)	Ve=vBl l? 0.
1 EXE (Enter value for ℓ.)	Ve=vBl Ve= 2.4^{-04}

96. Voltage Gain

$$A_v[dB] = 20 \log_{10}\left(\frac{V_2}{V_1}\right) \ [dB] \qquad (V_2/V_1 > 0)$$

V_1 is input voltage, V_2 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 $V_1 = 15V$ and an output voltage of $V_2 = 36V$.

Operation	Display
AC 96 FMLA (Recall voltage gain.)	Av=20log (V2/V → V2 ? 0.
36 EXE (Enter value for V_2.)	Av=20log (V2/V → V1 ? 0.
15 EXE (Enter value for V_1.)	Av=20log (V2/V → Av=7.604224834

97. Current Gain

$$A_i[dB] = 20\log_{10}\left(\frac{I_2}{I_1}\right)\ [dB] \qquad (I_2/I_1 > 0)$$

I_1 is input current, I_2 is output current

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

Example

Determine the current gain for an input current of $I_1 = 15$mA and an output current of $I_2 = 60$mA.

Operation	Display
AC 97 FMLA (Recall current gain.)	Ai=20log (I2/I I2? 0.
60 EXE (Enter value for I_2.)	Ai=20log (I2/I I1? 0.
15 EXE (Enter value for I_1.)	Ai=20log (I2/I Ai= 12.04119983

98. Power Gain

$$A_p[dB] = 10\log_{10}\left(\frac{P_2}{P_1}\right)[dB] \qquad (P_2/P_1>0)$$

P_1 is input power, P_2 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 $P_1=40$mW (40×10^{-3}W) and an output power of $P_2=5$W.

Opeartion	Display
AC 98 FMLA (Recall power gain.)	AP=10log (P2/P P2 ? 0.
5 EXE (Enter value for P_2.)	AP=10log (P2/P P1 ? 0.
40 EXP (−) 3 EXE (Enter value for P_1.)	AP=10log (P2/P AP = 20.96910013

99. Δ → Y conversion

$$R_4 = \frac{R_1R_2}{R_1+R_2+R_3}、 R_5 = \frac{R_2R_3}{R_1+R_2+R_3}、 R_6 = \frac{R_3R_1}{R_1+R_2+R_3}$$

$(R_1、R_2、R_3 > 0)$

• 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
AC 99 FMLA (Recall Δ → Y conversion.)	R4=R1R2/(R1+R2 R1? 0.
35 EXE (Enter value for R_1.)	R4=R1R2/(R1+R2 R2? 0.
90 EXE (Enter value for R_2.)	R4=R1R2/(R1+R2 R3? 0.
50 EXE (Enter value for R_3.)	R4=R1R2/(R1+R2 Disp R4= 18.
EXE	R5=R2R3/(R1+R2 Disp R5=25.71428571
EXE	R6=R3R1/(R1+R2 R6= 10.

100. Y → Δ Conversion

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

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

$$R_3 = \frac{R_4R_5 + R_5R_6 + R_6R_4}{R_4} \qquad (R_4, R_5, R_6 > 0)$$

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

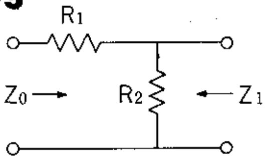
Example

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
AC 100 FMLA (Recall Y → Δ conversion.)	R1=(R4R5+R5R6+ R4? 0.
20 EXE (Enter value for R_4.)	R1=(R4R5+R5R6+ R5? 0.
30 EXE (Enter value for R_5.)	R1=(R4R5+R5R6+ R6? 0.
50 EXE (Enter value for R_6.)	R1=(R4R5+R5R6+ R1= 103.3333333
EXE	R2=(R4R5+R5R6+ R2= 62.
EXE	R3=(R4R5+R5R6+ R3= 155.

101. Minimum Loss Matching

$$R_1 = Z_0\sqrt{1-\frac{Z_1}{Z_0}}\ ,\quad R_2 = \frac{Z_1}{\sqrt{1-\frac{Z_1}{Z_0}}}$$



$$L_{min} = 20\log\left(\sqrt{\frac{Z_0}{Z_1}} + \sqrt{\frac{Z_0}{Z_1}-1}\right)\ [dB] \qquad (Z_0 \geqq Z_1 > 0)$$

Z is impedance

- This equation is used to determine R_1 and R_2 to match Z_0 and Z_1 with minimum loss.

Example

Determine the R_1, R_2 and L_{min} when $Z_0 = 500$ ohms and $Z_1 = 200$ ohms.

Operation	Display
AC 101 FMLA (Recall minimum loss matching.)	R1=Z0√(1−Z1/Z0 → Z0? 0.
500 EXE (Enter value for Z_0.)	R1=Z0√(1−Z1/Z0 → Z1? 0.
200 EXE (Enter value for Z_1.)	R1=Z0√(1−Z1/Z0 → R1=387.2983346
EXE	R2=Z1/√(1−Z1/Z → R2=258.1988897
EXE	Lm=20log(√(Z0 → Lm=8.961393328

102. Change in Terminal Voltage of R in RC Series Circuit

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

C is electrostatic capacity, R is resistance, t is time

•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 $t = 10$ when $R = 1M$ ohm (1×10^6 ohms), $C = 8\mu F$ ($8 \times 10^{-6}F$), and $V = 90V$.
(When $t = 0$, voltage of terminal $V_R = 0$)

Operation	Display
AC 1 0 2 FMLA (Recall change in terminal voltage of R in RC series circuit.)	VR=Ve(−t/CR) V? 0.
90 EXE (Enter value for V.)	VR=Ve(−t/CR) t? 0.
10 EXE (Enter value for t.)	VR=Ve(−t/CR) C? 0.
8 EXP (−) 6 EXE (Enter value for C.)	VR=Ve(−t/CR) R? 0.
1 EXP 6 EXE (Enter value for R.)	VR=Ve(−t/CR) VR=25.78543172

103. Probability Function of Binomial Distribution

$$P_x = {}_nC_x\, P^x\, (1-P)^{n-x} \qquad \begin{pmatrix} 0 \leqq P \leqq 1 \\ x = 0, 1, \cdots\cdots, n \\ n \text{ is positive integer} \end{pmatrix}$$

- This equation is used to determine the Px value for a phenomenon occurring in a binomial distribution when the probability P of the phenomenon and the frequency of appearance are known.

Example

Determine the Px value for a die thrown $n=6$ times with the frequency of occurrence of one being $x=2$ times. (P = 1/6)

Operation	Display
[AC] 103 [FMLA] (Recall probability function of binomial distribution.)	Px=nCxXPx^yxX(1 → n? 0.
6 [EXE] (Enter value for n.)	Px=nCxXPx^yxX(1 → x? 0.
2 [EXE] (Enter value for x.)	Px=nCxXPx^yxX(1 → P? 0.
1 [/] 6 [EXE] (Enter value for P.)	Px=nCxXPx^yxX(1 → Px=0.200938786

104. Probability Function of Poisson's Distribution

$$P_x = \frac{\mu^x e^{-\mu}}{x!} \qquad \begin{pmatrix} x = 0, 1, 2, \cdots\cdots \\ 0 < \mu \end{pmatrix}$$

- This equation is used to determine the Px value for Poisson's distribution when the mean and variance (both μ) are known and the frequency of occurrence is given.

Example

Determine the Px value for Poisson's distribution when the mean and variance are $\mu = 2$ and the frequency of occurrence is $x = 1$.

Operation	Display
AC 104 FMLA (Recall probability function of Poisson's distribution.)	Pχ=(μχʸχXe−μ)/ μ? 0.
2 EXE (Enter value for μ.)	Pχ=(μχʸχXe−μ)/ χ? 0.
1 EXE (Enter value for x.)	Pχ=(μχʸχXe−μ)/ Pχ=0.270670566

105. Probability Function of Geometric Distribution

$$P_x = (1-P)^x P \qquad \left(\begin{array}{l} x = 0, 1, 2, \cdots\cdots \\ 0 < P \leqq 1 \end{array}\right)$$

• This equation is used to determine the Px value for each appearance x of a phenomenon when the probability P is known.

Example

Determine the Px value when $P = 1/4$ and $x = 2$.

Operation	Display
AC 105 FMLA (Recall probability function of geometric distribution.)	Pχ=(1−P)χʸχXP P? 0.
1 ◢ 4 EXE (Enter value for P.)	Pχ=(1−P)χʸχXP χ? 0.
2 EXE (Enter value for x.)	Pχ=(1−P)χʸχXP Pχ= 0.140625

106. Probability Function of Hypergeometric Distribution

$$P_x = \frac{{}_kC_x \cdot {}_{N-k}C_{n-x}}{{}_NC_n} \qquad \left(\begin{array}{l} 0 \leqq k \leqq N,\ 0 \leqq n \leqq N \\ N,\ k \text{ and } x \text{ are} \\ \text{positive integers} \end{array}\right)$$

- This equation is used to determine probability when the values for N, n, k, and x are known.

Example

A total of $k=3$ defective articles can be expected within a total of $N=40$. Determine the probability of $x=1$ defective article being found among a sample of ten articles taken from the 40.

Operation	Display
AC 106 FMLA (Recall probability function of hypergeometric distribution.)	Pχ=kCχX(N−k)C(k? 0.
3 EXE (Enter value for k.)	Pχ=kCχX(N−k)C(χ? 0.
1 EXE (Enter value for x.)	Pχ=kCχX(N−k)C(N? 0.
40 EXE (Enter value for N.)	Pχ=kCχX(N−k)C(n? 0.
10 EXE (Enter value for n.)	Pχ=kCχX(N−k)C(Pχ= 0.4402834

107. Probability Function of Exponential Distribution

$$y = \lambda e^{-\lambda x} \quad x > 0$$
$$y = 0 \qquad x \leqq 0 \qquad (\lambda > 0)$$

λ is inverse of expected value

- This equation is used to determine a value for y in relation to the x value when the λ value is known.

Example

Determine the value of y when the expected value is 2 (λ = 1/2) and x is 1.

Operation	Display
AC 1 0 7 FMLA (Recall probability function of exponential distribution.)	y=λe(−λx) λ? 0.
1 ◢ 2 EXE (Enter value for λ.)	y=λe(−λx) x? 0.
1 EXE (Enter value for x.)	y=λe(−λx) y= 0.303265329

108. Probability Function of Uniform Distribution

$$y=\frac{1}{b-a} \qquad a<x<b$$

$$y=0 \qquad x \leqq a、 x \leqq b$$

• This equation is used to determine the value for the probability function of uniform distribution when a and b are known.

Example

Determine the value for the probability function of uniform distribution when $a=1$ and $b=12$.

Operation	Display
AC 108 FMLA (Recall probability function of uniform distribution.)	y=1/(b−a) b? 0.
12 EXE (Enter value for b.)	y=1/(b−a) a? 0.
1 EXE (Enter value for a.)	y=1/(b−a) y= 0.09090909

109. Normal Distribution (Probability Density Function)

$$y=\frac{1}{\sqrt{2\pi}\,\sigma}e^{-\frac{(x-\mu)^2}{2\sigma^2}} \qquad (\sigma>0)$$

- This equation is used to determine the value for normal distribution (probability density function) when the mean value of the distribution μ and variance σ^2 are given.

Example

Determine the value for $x=35$ normal distribution (probability density function) when $\mu=33$ and $\sigma=4$.

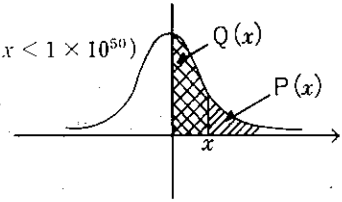
Operation	Display
AC 109 FMLA (Recall normal distribution (probability density function).)	y=(1/(√(2π)×σ) σ? 0.
4 EXE (Enter value for σ.)	y=(1/(√(2π)×σ) x? 0.
35 EXE (Enter value for x.)	y=(1/(√(2π)×σ) μ? 0.
33 EXE (Enter value for μ.)	y=(1/(√(2π)×σ) y= 0.088016331

110. Normal Probability Function

$$P(x) = \frac{1}{\sqrt{2\pi}} \int_{|x|}^{\infty} e^{-\frac{t^2}{2}} dt \qquad (0 \leqq x < 1 \times 10^{50})$$

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

(Hastings' best estimate formula.)



- This equation is used to determine the normal probability function $P(x)$, $Q(x)$ when a value for x is known.
- Since this is an approximation formula, precision may be questionable.

Example

Determine the normal probability function $P(x)$ and $Q(x)$ when $x=3$.

Operation	Display
AC 1 1 0 FMLA (Recall normal probability function.)	P(χ) Q(χ) χ? 0.
3 EXE (Enter value for x.)	P(χ) Q(χ) t=0.589996363
EXE	P(χ) Q(χ) Pχ=1.349968527^{-03}
EXE	P(χ) Q(χ) Qχ=0.498650031

111. Deviation

$$y = \frac{x - x_A}{\sigma} \times 10 + 50 \quad (\sigma > 0)$$

x_A is mean, σ is standard deviation

• This equation is used to determine the deviation when the mean and standard deviation are known.

Example

Determine the deviation from $x = 65.1$ when the mean is $x_A = 63.8$ and the standard deviation is $\sigma = 4.2$.

Operation	Display
AC 1 1 1 FMLA (Recall deviation.)	y=(χ−χA)×10/σ+ χ? 0.
65.1 EXE (Enter value for x.)	y=(χ−χA)×10/σ+ χA? 0.
63.8 EXE (Enter value for x_A.)	y=(χ−χA)×10/σ+ σ? 0.
4.2 EXE (Enter value for σ.)	y=(χ−χA)×10/σ+ y= 53.0952381

112. Tension and Compression

$$\lambda = \frac{\sigma}{E}\ell \qquad (E,\ \sigma,\ \ell > 0)$$

σ is vertical stress, ℓ is original length, E is Young's modulus

- This equation is used to determine the stretch or compression when the vertical stress, Young's modulus, and the original length of the material are known. The vertical stress is $\sigma = \frac{W}{A}$ for vertical load W and A is the original cross sectional area of the material.

Example

Determine the stretch or compression volume when length $\ell = 420$mm, vertical stress $\sigma = 4.0$ kgf/mm^2, and Young's modulus $E = 1.8 \times 10^4$ kgf/mm^2.

Operation	Display
AC 1 1 2 FMLA (Recall tension and compression.)	λ=σl/E σ? 0.
4 EXE (Enter value for σ.)	λ=σl/E l? 0.
420 EXE (Enter value for ℓ.)	λ=σl/E E? 0.
1.8 EXP 4 EXE (Enter value for E.)	λ=σl/E λ= 0.093333333

113. Shearing Stress (1)

$$\tau = \frac{P}{A} \qquad (A, P > 0)$$

P is shear load; A is cross sectional area receiving the shear

- This equation is used to determine the shearing stress when the shear load and cross sectional area receiving the shear are known.

Example

Determine the shearing stress when the shear load is $P = 90$kg and the cross sectional area receiving the shear is $A = 16\text{mm}^2$.

Operation	Display
AC 1 1 3 FMLA (Recall shearing stress (1).)	τ=P/A P?　　0.
90 EXE (Enter value for P.)	τ=P/A A?　　0.
16 EXE (Enter value for A.)	τ=P/A τ=　　5.625

114. Shearing Stress (2)

$\tau = G\gamma \qquad (G, \gamma > 0)$

G is transversability coefficient, γ is shearing strain

- This equation is used to determine the shearing stress when the transversability coefficient and the shearing strain are known.

Example

Determine the shearing stress when the shearing strain is $\gamma = 0.0007$ and the transversability coefficient is $G = 1.1 \times 10^4$ kgf/mm^2.

Operation	Display
AC 1 1 4 FMLA (Recall shearing stress (2).)	τ=Gγ G? 0.
1.1 EXP 4 EXE (Enter value for G.)	τ=Gγ γ? 0.
0.0007 EXE (Enter value for γ.)	τ=Gγ τ= 7.7

115. Enthalpy

$$i = u + \frac{Pv}{J} \qquad (u, P, v, J > 0)$$

u is internal energy, P is pressure, v is volume, J is mechanical equivalent of heat

- This equation is used to determine enthalpy when the internal energy, pressure and volume are known.

Example

Determine enthalpy when the internal energy $u = 1$ cal, pressure $P = 1$atm (101.3 N/m^2), and volume $v = 11.2\ell$. Note that $J = 4.19$ J/cal.

Operation	Display
AC 1 1 5 FMLA (Recall enthalpy.)	i=u+Pv/J u? 0.
1 EXE (Enter value for u.)	i=u+Pv/J P? 0.
101.3 EXE (Enter value for P.)	i=u+Pv/J v? 0.
11.2 EXE (Enter value for v.)	i=u+Pv/J J? 0.
4.19 EXE (Enter value for J.)	i=u+Pv/J i = 271.778043

116. Efficiency of Carnot's Cycle (1)

$$\eta = \frac{Q_1 - Q_2}{Q_1} \qquad (Q_1 \neq 0)$$

Q is volume of heat

- This equation is used to determine efficiency of Carnot's cycle when the low temperature heat volume and high temperature heat volume are known.

Example

Determine the efficiency of Carnot's cycle when low temperature heat source $Q_2 = 250$ Kcal/h and high temperature heat source $Q_1 = 1400$ Kcal/h.

Operation	Display
AC 116 FMLA (Recall efficiency of Carnot's cycle (1).)	η=(Q1−Q2)/Q1 Q1? 0.
1400 EXE (Enter value for Q_1.)	η=(Q1−Q2)/Q1 Q2? 0.
250 EXE (Enter value for Q_2.)	η=(Q1−Q2)/Q1 η= 0.8214285714

117. Efficiency of Carnot's Cycle (2)

$$\eta = \frac{T_1 - T_2}{T_1} \qquad (T_1 \neq 0)$$

T is temperature

- This equation is used to determine efficiency of Carnot's cycle when the low temperature heat source and high temperature heat source are known.

Example

Determine the efficiency of Carnot's cycle when $T_2 = 273.15$K (freezing point of water) and $T_1 = 373.15$K (boiling point of water).

Operation	Display
AC 1 1 7 FMLA (Recall efficiency of Carnot's cycle (2).)	η=(T1−T2)/T1 T1? 0.
373.15 EXE (Enter value for T_1.)	η=(T1−T2)/T1 T2? 0.
273.15 EXE (Enter value for T_2.)	η=(T1−T2)/T1 η=0.267988744

118. Bernoulli's Theorem (1)

$$\left[\frac{P}{\gamma}+\frac{v^2}{2g}+Z=\text{Constant}\right]$$

$$P_2=P_1+\gamma\left(\frac{v_1{}^2-v_2{}^2}{2g}+Z_1-Z_2\right) \quad (v、P、\gamma、Z>0)$$

P is pressure, γ is specific weight, v is flow velocity, Z is height, g is gravitational velocity

- This equation is used to determine pressure at two points for an inviscid fluid when the flow velocity and location (height) of two points, the pressure at one point, and the specific weight are known.

Example

Determine the pressure at POINT 2 for water (specific weight $\gamma=1000$ kgf/m^3) with a pressure $P_1=3000$ kgf/m^2 and flow velocity $v_1=6$ m/s at POINT 1 (height $Z_1=4$m), and flow velocity $v_2=5$ m/s at POINT 2 (height $Z_2=2$m).

Operation	Display
AC 118 FMLA (Recall Bernoulli's theorem (1).)	P/γ+V²/2g+Z=Co P1 ? 0.
3000 EXE (Enter value for P_1.)	P/γ+V²/2g+Z=Co V1 ? 0.
6 EXE (Enter value for v_1.)	P/γ+V²/2g+Z=Co V2 ? 0.
5 EXE (Enter value for v_2.)	P/γ+V²/2g+Z=Co γ ? 0.

1000 [EXE]
(Enter value for γ.)

P/γ+V²/2g+Z=Co
Z1? 0.

4 [EXE]
(Enter value for Z_1.)

P/γ+V²/2g+Z=Co
Z2? 0.

2 [EXE]
(Enter value for Z_2.)

P/γ+V²/2g+Z=Co
P2 = 5560.843917

119. Bernoulli's Theorem (2)

$$\left[\frac{P}{\gamma}+\frac{v^2}{2g}+Z=\text{Constant}\right]$$

$$v_2=\sqrt{\frac{2g(P_1-P_2)}{\gamma}+v_1{}^2+2g(Z_1-Z_2)} \quad (v,\ P,\ \gamma,\ Z>0)$$

P is pressure, γ is specific weight, v is flow velocity, Z is height, g is gravitational velocity

- This equation is used to determine flow velocity at two points for an inviscid fluid when the pressure and location (height) of two points, the flow velocity at one point, and the specific weight are known.

Example

Determine the flow velocity at POINT 2 for water (specific weight $\gamma=1000$ kgf/m^3) with a pressure $P_1=4000$ kgf/m^2 and flow velocity $v_1=5$ m/s at POINT 1 (height $Z_1=6$m), and pressure $P_2=4200$ kgf/m^2 at POINT 2 (height $Z_2=5$m).

Operation	Display
AC 1 1 9 FMLA (Recall Bernoulli's theorem (2).)	P/γ+V²/2g+Z=Co P1 ? 0.
4000 EXE (Enter value for P_1.)	P/γ+V²/2g+Z=Co P2 ? 0.
4200 EXE (Enter value for P_2.)	P/γ+V²/2g+Z=Co γ ? 0.
1000 EXE (Enter value for γ.)	P/γ+V²/2g+Z=Co V1 ? 0.

5 [EXE]
(Enter value for v_1.)

P/γ+V²/2g+Z=C0
Z1 ? 0.

6 [EXE]
(Enter value for Z_1.)

P/γ+V²/2g+Z=C0
Z2 ? 0.

5 [EXE]
(Enter value for Z_2.)

P/γ+V²/2g+Z=C0
V2 = 6.378921539

120. Bernoulli's Theorem (3)

$$\left[\frac{P}{\gamma}+\frac{v^2}{2g}+Z=\text{Constant}\right]$$

$$Z_2=\frac{P_1-P_2}{\gamma}+\frac{v_1{}^2-v_2{}^2}{2g}+Z_1 \quad (v,\ P,\ \gamma,\ Z>0)$$

P is pressure, γ is specific weight, ν is flow velocity, Z is height, g is gravitational velocity

• This equation is used to determine the position of POINT 2 for an inviscid fluid when the pressure and flow velocity of two points, the position (height) at one point, and the specific weight are known.

Example

Determine the position at POINT 2 for a liquid (specific weight $\gamma = 1000$ kgf/m^3) with a pressure $P_1 = 20{,}000$ kgf/m^2 and flow velocity $\nu_1 = 1.6$ m/s at POINT 1 (height $Z_1 = 5$m), and pressure $P_2 = 21{,}790$ kgf/m^2 and flow velocity $\nu_2 = 2.6$ m/s at POINT 2.

Operation	Display
AC 1 2 0 FMLA (Recall Bernoulli's theorem (3).)	P/γ+V²/2g+Z=Co P1 ? 0.
20000 EXE (Enter value for P_1.)	P/γ+V²/2g+Z=Co P2 ? 0.
21790 EXE (Enter value for P_2.)	P/γ+V²/2g+Z=Co γ ? 0.
1000 EXE (Enter value for γ.)	P/γ+V²/2g+Z=Co V1 ? 0.

1.6 [EXE] (Enter value for v_1.)	P/γ+V²/2g+Z=Co V2?　　　　0.
2.6 [EXE] (Enter value for v_2.)	P/γ+V²/2g+Z=Co Z1?　　　　0.
5 [EXE] (Enter value for Z_1.)	P/γ+V²/2g+Z=Co Z2=2.995859595

121. Equation of Continuity (1)

$A_1 v_1 \rho_1 = A_2 v_2 \rho_2 =$ Constant $(A_2, \rho_2 > 0)$

A_1 and A_2 are cross sectional areas of ducts, ν_1 and ν_2 are flow velocities, ρ_1 and ρ_2 are densities of liquids

- This equation is used to determine the flow velocity of a liquid at a point when the cross sectional area of a duct and the density of the liquid are known and the weight flow is constant.

Example

Determine the flow velocity when the cross sectional area of a duct is $A_2 = 0.09\text{m}^2$, if the velocity is $\nu_1 = 0.4\text{m/s}$ when the area is $A_1 = 0.04\text{m}^2$, and density of the liquid is $\rho_1 = \rho_2 = 1\text{g/cm}^3$.

Operation	Display
AC 1 2 1 FMLA (Recall equation of continuity (1).)	A1V1P1=A2V2P2= A1 ? 0.
0.04 EXE (Enter value for A_1.)	A1V1P1=A2V2P2= V1 ? 0.
0.4 EXE (Enter value for ν_1.)	A1V1P1=A2V2P2= P1 ? 0.
1 EXE (Enter value for ρ_1.)	A1V1P1=A2V2P2= A2 ? 0.
0.09 EXE (Enter value for A_2.)	A1V1P1=A2V2P2= P2 ? 0.
1 EXE (Enter value for ρ_2.)	A1V1P1=A2V2P2= V2 = 0.177777777

122. Equation of Continuity (2)

$$A_1 v_1 \rho_1 = A_2 v_2 \rho_2 = \text{Constant} \quad (v_2 \neq 0,\ \rho_2 > 0)$$

A_1 and A_2 are cross sectional areas of ducts, v_1 and v_2 are flow velocities, ρ_1 and ρ_2 are densities of liquids

- This equation is used to determine the cross sectional area of a duct when the flow velocity of a liquid at a point and the density of the liquid are known and the weight flow is constant.

Example

Determine the cross sectional area of a duct when the flow velocity is $v_2 = 3.5$ m/s, if the velocity is $v_1 = 2.5$m/s when the area is $A_1 = 0.12\text{m}^2$, and density of the liquid is $\rho_1 = \rho_2 = 1\text{g/cm}^3$.

Operation	Display
AC 1 2 2 FMLA (Recall equation of continuity (2).)	A1V1P1=A2V2P2= A1? 0.
0.1 2 EXE (Enter value for A_1.)	A1V1P1=A2V2P2= V1? 0.
2.5 EXE (Enter value for v_1.)	A1V1P1=A2V2P2= P1? 0.
1 EXE (Enter value for ρ_1.)	A1V1P1=A2V2P2= V2? 0.
3.5 EXE (Enter value for v_2.)	A1V1P1=A2V2P2= P2? 0.
1 EXE (Enter value for ρ_2.)	A1V1P1=A2V2P2= A2 = 0.085714285

123. Module (1)

$$\left[M = \frac{D_1}{Z_1} = \frac{D_2}{Z_2} = \frac{P}{\pi} \right]$$

$$M = \frac{D}{Z}$$ (D, Z>0, and are integers)

D is pitch diameter of a gear, Z is number of teeth on the gear

- This equation is used to determine the module when the pitch diameter of a gear and the number of teeth on the gear are known.

Example

Determine the module for a gear with Z = 24 teeth and a pitch diameter of D = 36mm.

Operation	Display
AC 1 2 3 FMLA (Recall Module (1).)	M=D/Z D? 0.
36 EXE (Enter value for D.)	M=D/Z Z? 0.
24 EXE (Enter value for Z.)	M=D/Z M= 1.5

124. Module (2)

$$\left[M = \frac{D_1}{Z_1} = \frac{D_2}{Z_2} = \frac{P}{\pi} \right]$$

$$M = \frac{P}{\pi} \qquad (P > 0)$$

P is pitch of a gear

- This equation is used to determine the module when the pitch of a gear is known.

Example

Determine the module for a gear with a pitch of $P = 6$mm.

Operation	Display
AC 1 2 4 FMLA (Recall Module (2).)	M=P/π P? 0.
6 EXE (Enter value for P.)	M=P/π M= 1.909859317

125. Module (3)

$$\left[M = \frac{D_1}{Z_1} = \frac{D_2}{Z_2} = \frac{P}{\pi} \right]$$

$$D_2 = \frac{D_1 Z_2}{Z_1} \qquad \begin{pmatrix} D_1 \text{、} Z_1 \text{、} Z_2 > 0 \\ Z_1 \text{ and } Z_2 \text{ are integers} \end{pmatrix}$$

D_1 is pitch diameter of driving gear, D_2 is pitch diameter of driven gear, Z_1 is number of teeth on driving gear, Z_2 is number of teeth on driven gear

- This equation is used to determine the pitch diameter of the driven gear when the driving gear's pitch diameter and number of teeth are known, and the driven gear's number of teeth are known.

Example

Determine the pitch diameter of a driven gear when the pitch diameter of the driving gear is $D_1 = 15$mm, the number of teeth is $Z_1 = 32$, and the number of teeth on the driven gear is $Z_2 = 46$.

Operation	Display
AC 1 2 5 FMLA (Recall Module (3).)	D2=D1Z2/Z1 D1 ?　　0.
1 5 EXE (Enter value for D_1.)	D2=D1Z2/Z1 Z2 ?　　0.
46 EXE (Enter value for Z_2.)	D2=D1Z2/Z1 Z1 ?　　0.
32 EXE (Enter value for Z_1.)	D2=D1Z2/Z1 D2 =　　21.5625

126. Module (4)

$$\left[M = \frac{D_1}{Z_1} = \frac{D_2}{Z_2} = \frac{P}{\pi} \right]$$

$$D = \frac{PZ}{\pi}$$ (P, Z > 0, and are integers)

P is pitch of a gear, Z is number of teeth on the gear

- This equation is used to determine the pitch diameter of a gear when its pitch and number of teeth on the gear are known.

Example

Determine the pitch diameter for a gear with Z = 84 teeth and a pitch of P = 2.22mm.

Operation	Display
AC 1 2 6 FMLA (Recall Module (4).)	D=PZ/π P? 0.
2.22 EXE (Enter value for P.)	D=PZ/π Z? 0.
84 EXE (Enter value for Z.)	D=PZ/π D=59.35842758

127. Reynold's Number

$$R = \frac{u\ell}{\nu} \qquad (\nu \neq 0)$$

u is flow velocity, ℓ is inside diameter of duct, ν is kinematic viscosity

- This equation is used to determine the Reynold's number when the velocity, duct inner diameter, and kinematic viscosity are known for a liquid flowing through a duct.

Example

Determine the Reynold's number for liquid flowing at velocity $u = 0.3$ m/s through a duct with an inner diameter $\ell = 80$mm when the kinematic viscosity of the liquid is $\nu = 1.004 \times 10^{-6} m^2/s$.

Operation	Display
AC 127 FMLA (Recall Reynold's number.)	R=ul/ν u? 0.
0.3 EXE (Enter value for u.)	R=ul/ν l? 0.
80 EXP (−) 3 EXE (Enter value for ℓ.)	R=ul/ν ν? 0.
1.004 EXP (−) 6 EXE (Enter value for ν.)	R=ul/ν R=23904.38247

128. Calculations Using a Stadia

$$S = K\ell \cos^2 \alpha + C \cos \alpha \quad \text{(Horizontal distance)}$$

$$h = \frac{1}{2} K\ell \sin 2\alpha + C \sin \alpha \quad \text{(Difference in Elevation)} \begin{pmatrix} 0 \leq \alpha \leq 90^\circ \\ K, \ell, C > 0 \end{pmatrix}$$

K and C are stadia constants, α is angle of elevation

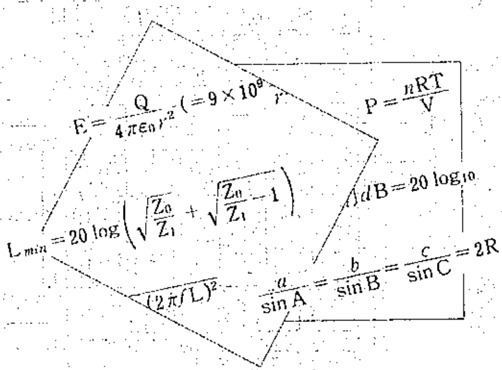
- This equation is used to determine the horizontal distance from the transit to the leveling rod by reading the angle of elevation when a transit is used to read the length of the leveling rod between the upper and lower stadia lines.

Example

Determine the horizontal distance between two points and the elevation difference between the transit point and leveling rod when the length on the leveling rod between the upper and lower stadia lines is $\ell = 0.865$m, and the elevation difference is $\alpha = +4$. Note that $K = 100$ and $C = 0$.

Operation	Display
MODE 4 EXE (Degree)	
AC 128 FMLA (Recall calculations using a stadia.)	S=Kl(cos α)²+C K? 0.
100 EXE (Enter value for K.)	S=Kl(cos α)²+C l? 0.
0.865 EXE (Enter value for ℓ.)	S=Kl(cos α)²+C α? 0.
4 EXE (Enter value for α.)	S=Kl(cos α)²+C C? 0.
0 EXE (Enter value for C.)	S=Kl(cos α)²+C S=86.07909397
EXE	h=(1/2)Klsin 2 h=6.019236617

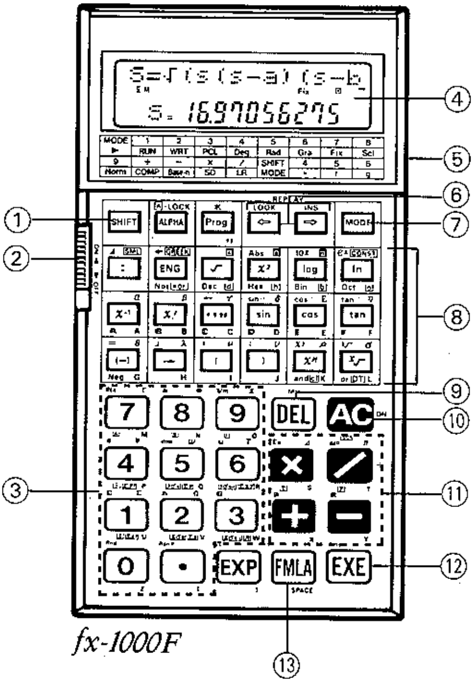
Appendices



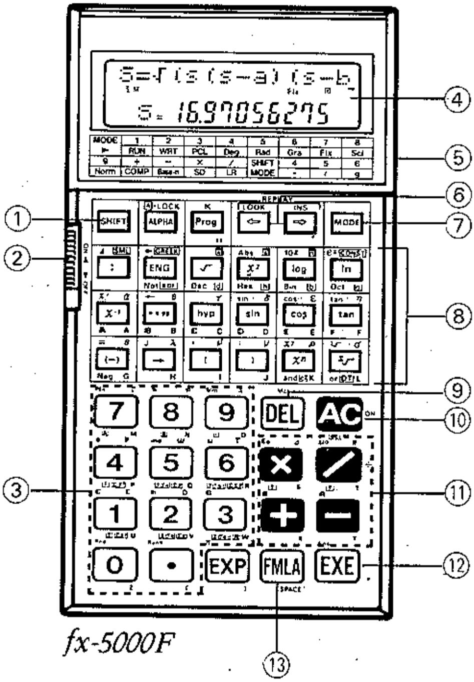
$P = \frac{nRT}{V}$
$E = \frac{Q}{4\pi\varepsilon_0 r^2} (= 9 \times 10^9$
$dB = 20 \log_{10}$
$L_{min} = 20 \log\left(\sqrt{\frac{Z_0}{Z_1}} + \sqrt{\frac{Z_0}{Z_1} - 1}\right)$
$(2\pi f L)^2$
$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} = 2R$

Appendix A | Keys and Indicators

■ General Guide



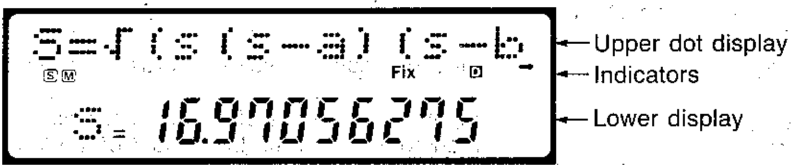
fx-1000F



fx-5000F

① Shift key
② Power switch
③ Number keys
④ Display
⑤ Contrast dial
⑥ Cursor/Replay keys
⑦ Mode key
⑧ Function keys
⑨ Delete key
⑩ All clear key
⑪ Arithmetic operation keys
⑫ Execute key
⑬ Formula key

■ Display



•Upper dot display

- The upper dot display is used for calculations and formulas.
- The number zero is shown on the display with a diagonal line to differentiate it from the letter "O".
- The blinking line in the upper dot display is called the "cursor" and it shows you where a character will appear when you input something.
- The symbols "←" and "→" tell you when the currently displayed formula or value is so large that it runs off the left or right of the display.

•Indicators

Ⓢ .... SHIFT key was pressed.
Ⓜ .... MODE key was pressed.
Ⓐ .... ALPHA key was pressed.
X^n .... x^n was pressed.
hyp .... hyp key was pressed. (fx-5000F)
WRT ...... Indicates WRT mode.
PCL .... Indicates PCL mode.
Disp .... Appears when the calculation is stopped for a result display.
LR .... Indicates LR mode.
SD .... Indicates SD mode.
Fix .... Indicates number of decimal places specified.
Sci .... Indicates number of significant digits specified.
D .... Indicates degrees specified for unit of angular measurement.
R .... Indicates radians specified for unit of angular measurement.
G .... Indicates grads specified for unit of angular measurement.

•Lower display

- The lower display is used to show calculation results, variable input, and the values assigned to variables.
- This display also shows the number of steps remaining in memory when you are storing a user formula.
- The " ◀ " indicator on the left of the display tells you that other calculation results follow, and can be displayed by pressing the EXE key again.

■ Power switch

Slide the switch up to turn power ON and down to turn power OFF.

■ Key Operations and Their Functions

Key Operation	Application
SHIFT	Input of functions marked in brown above the input keys.
ALPHA	Input of upper case alphabetic characters and symbols marked in red at the lower right of the keys.
SHIFT ALPHA (A·LOCK)	Lock for continuous input of multiple alphabetic characters.
ALPHA	Unlocks continuous input of multiple alphabetic characters.
Prog	Executes a user formula when pressed before a user formula memory name entry.
SHIFT Prog (IK)	Input or recall of constant memories.
ALPHA Prog ('')	Encloses messages in quotation marks.
⇦	Moves cursor to the left. Hold down for high speed movement.
⇨	Moves cursor to the right. Hold down for high speed movement.
EXE ⇦	Locates cursor at end of calculation formula or value when EXE is used for input.
EXE ⇨	Locates cursor at beginning of calculation formula or value when EXE is used for input.
SHIFT ⇦ (LOOK)	Displays formula on upper dot display during input of values for variables in formula calculations.
SHIFT ⇨ (INS)	Enters insert mode for insertion of characters or functions within a calculation for formula.
MODE	Used in combination with other keys for a variety of functions.
MODE 1	For manual calculations and execution of formulas stored in memory.
MODE 2	WRT mode for writing and checking of user formulas.
MODE 3	PCL mode for clearing of user formulas from memory.
MODE 4 EXE	Changes unit of angular measurement to degrees.

Key Operation	Application
MODE 5 EXE	Changes unit of angular measurement to radians.
MODE 6 EXE	Changes unit of angular measurement to grads.
MODE 7 n EXE	Sets number of decimal places as 0 ~ 9. *n = 0 ~ 9 (integer)
MODE 8 n EXE	Sets number of significant digits as 1 ~ 10. *n = 0 ~ 9 (integer)
MODE 9 EXE	Cancels number of decimal places or number of significant digits specification.
MODE +	COMP mode for arithmetic or scientific calculations.
MODE −	Binary/octal/decimal/hexadecimal conversions and calculations.
MODE ×	SD mode for standard deviation calculations.
MODE ÷	LR mode for regression calculations.
SHIFT MODE 4	Specifies degrees as unit for input value.
SHIFT MODE 5	Specifies radians as unit for input value.
SHIFT MODE 6	Specifies grads as unit for input value.
:	Inputs a colon to connect two calculations into a single calculation.
SHIFT ◢ :	Inputs a "◢" to connect two calculations into a single calculation.
ALPHA SML :	Input of lower case alphabetic characters marked in red at the lower right of the keys.
ENG (SHIFT $\overleftarrow{\text{ENG}}$)	Converts values to equivalent engineering units by shifting the decimal place to the left or right and adjusting the exponent display. (10^3=K, 10^6=M, 10^9=G, 10^{-3}=m, 10^{-6}=μ, 10^{-9}=n, 10^{-12}=p).
ENG Not	In the Base-n mode, inputs NOT for logical operations.
SHIFT ENG xor	Inputs XOR in the Base-n mode.

Key Operation	Application
ALPHA GREEK/ENG	Input of Greek characters marked in red at the upper right of the keys.
√	Returns the square root of the following value.
√ (Dec) EXE	Specifies decimal calculations in the base-n mode.
SHIFT √ (d)	Specifies the next value input is decimal value in the base-n mode.
ALPHA √ (A)	Input of upper case characters marked in red at the lower right of the keys as suffixes.
x^2	Returns the square of the previously entered value.
SHIFT Abs/x^2	Returns the absolute value of the following value.
SHIFT x^2 (h)	Specifies the next value input is hexadecimal value in the base-n mode.
x^2 (Hex) EXE	Specifies hexadecimal calculations in the base-n mode.
ALPHA x^2 (a)	Input of lower case characters marked in red at the lower right of the keys as suffixes.
log	Returns the common logarithm of the following value.
SHIFT 10^x/log	Makes following value exponent of 10.
log (Bin) EXE	Specifies binary calculations in the base-n mode.
SHIFT log (b)	Specifies the next value input is binary value in the base-n mode.
ALPHA log (n)	Specifies following numeric input is for small numbers used for suffixes.
ln	Returns the natural logarithm of the following value.
SHIFT e^x/ln	Makes following value exponent of e.
ln (Oct) EXE	Specifies octal calculations in the base-n mode.
SHIFT ln (o)	Specifies the next value input is octal value in the base-n mode.
ALPHA CONST/ln	Input of constants marked in red at the upper left of the keys.

Key Operation	Application
x^{-1}	Returns reciprocal of previously entered value.
x^{-1} /A	Inputs hexadecimal value A in the base-*n* mode.
$x!$	Returns factorial of previously entered value. *With the fx-5000F, press SHIFT x^{-1} ($x!$) .
°' "	Used to input sexagesimal value as degrees, minutes, seconds (ex. 78°45'12"→78 °' " 45 °' " 12 °' ").
°' " B	Inputs hexadecimal value B in base-*n* mode.
SHIFT ← °' "	Displays decimal value in degree/minute/second format.
hyp C	Inputs hexadecimal value C in base-*n* mode.
hyp sin	Returns the hyperbolic sine (sinh) of the following value.
hyp cos	Returns the hyperbolic cosine (cosh) of the following value.
hyp tan	Returns the hyperbolic tangent (tanh) of the following value.
SHIFT hyp $\sin^{-1}$ sin	Returns the inverse hyperbolic sine ($\sinh^{-1}$) of the following value.
SHIFT hyp $\cos^{-1}$ cos	Returns the inverse hyperbolic cosine ($\cosh^{-1}$) of the following value.
SHIFT hyp $\tan^{-1}$ tan	Returns the inverse hyperbolic tangent ($\tanh^{-1}$) of the following value.
sin	Returns the sine of the following value.
sin D	Inputs the hexadecimal value D in the base-*n* mode.
SHIFT $\sin^{-1}$ sin	Returns the arc sine ($\sin^{-1}$) of the following value.
cos	Returns the cosine of the following value.
cos E	Inputs the hexadecimal value E in the base-*n* mode.
SHIFT $\cos^{-1}$ cos	Returns the arc cosine ($\cos^{-1}$) of the following value.

Key Operation	Application
[tan]	Returns the tangent of the following value.
[tan] F	Inputs the hexadecimal value F in the base-n mode.
[SHIFT] [tan] ($\tan^{-1}$)	Returns the arc tangent ($\tan^{-1}$) of the following value.
[(−)]	Enters the following value as negative.
[(−)] Neg	Returns the negative of the following value in the base-n mode. Negatives are expressed as twos' complements in the base-n mode.
[SHIFT] [(−)] (=)	Inputs equal sign (=).
[→]	Indicates that a calculation result is to be stored in the memory indicated by the following specification.
[SHIFT] [→] (┘)	Inputs a "┘" to connect two calculations into a single calculation.
[(]	Inputs an open parentheses into a formula.
[SHIFT] [(] (,)	Inputs a comma to separate arguments in statistical calculations.
[)]	Inputs a closed parentheses into a formula.
[SHIFT] [)] (;)	Inputs a semicolon to separate arguments in statistical calculations.
x [x^n] n	Returns x (any value) to the nth (positive integer) power.
x [SHIFT] [x^n] (x^y) y	Returns x (any value) to the yth (any value) power.
[x^n] and	Inputs logical AND in the base-n mode.
[x^n] cl	Clears a specific data in the SD and LR modes.
x [$\sqrt[x]{\ }$] y	Returns x root of y.
[SHIFT] [$\sqrt[x]{\ }$] ($\sqrt[3]{\ }$)	Returns cube root of following value.
[$\sqrt[x]{\ }$] DT	In the SD and LR modes, inputs data.

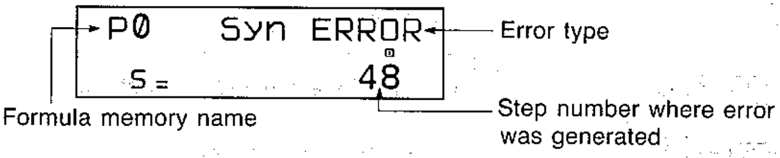
Key Operation	Application
SHIFT $\sqrt[x]{\ }$	Inputs $\sqrt[x]{\ }$ in the SD and LR modes.
$\sqrt[x]{\ }$ or	Inputs logical OR in the base-n mode.
0 ~ 9 •	Used for input of numbers and the decimal point.
SHIFT Rnd 0	Rounds the internal value to the number of decimal places specified by MODE 7 or number of significant digits specified by MODE 8.
SHIFT Ran# •	Generates a pseudorandom number between 0.000 and 0.999.
SHIFT 1 ($\bar{x}$) EXE	Returns the mean of x-data in the SD or LR mode.
SHIFT IK Prog 1 (Σx^2) EXE	Returns the sum of squares of x-data in the SD or LR mode.
ALPHA CONST ln c 1	Speed of light in vacuum (c).
SHIFT 2 ($x\sigma_n$) EXE	Returns the population standard deviation of x-data in the SD or LR mode.
SHIFT IK Prog 2 (Σx) EXE	Returns the sum of x-data in the SD or LR mode.
ALPHA CONST ln h 2	Planck's constant (h)
SHIFT 3 ($x\sigma_{n-1}$) EXE	Returns the sample standard deviation of x-data in the SD or LR mode.
SHIFT IK Prog 3 (n) EXE	Returns the number of data in the SD or LR mode.
ALPHA CONST ln G 3	Gravitational constant (G)
SHIFT 4 ($\bar{y}$) EXE	Returns the mean of y-data in the LR mode.
SHIFT IK Prog 4 (Σy^2) EXE	Returns the sum of squares of y-data in the LR mode.
ALPHA CONST ln e 4	Elementary charge (e)
SHIFT 5 ($y\sigma_n$) EXE	Returns the population standard deviation of y-data in the LR mode.
SHIFT IK Prog 5 (Σy) EXE	Returns the sum of y-data in the LR mode.
ALPHA CONST ln me 5	Electron rest mass (me)

Key Operation	Application
[SHIFT] [6] [EXE]	Returns the sample standard deviation of y-data in the LR mode.
[SHIFT] [Prog] [6] [EXE]	Returns the sum of products of x and y-data in the LR mode.
[ALPHA] [ln] [6]	Atomic mass unit (u)
[SHIFT] [7] [EXE]	Returns constant term of regression formula (A) in the LR mode.
[ALPHA] [ln] [7]	Avogadro constant (N_A)
[SHIFT] [8] [EXE]	Returns regression coefficient (B) in the LR mode.
[ALPHA] [ln] [8]	Boltzman constant (k)
[SHIFT] [9] [EXE]	Returns correlation coefficient (r) in the LR mode.
[ALPHA] [ln] [9]	Molar volume of ideal gas at s.t.p. (Vm)
[EXP]	Enters the following value as an exponent.
[SHIFT] [EXP]	Inputs pi.
[DEL]	Deletes the character or function at the current location of the cursor.
[SHIFT] [DEL]	Clears the contents of all user formulas in the PCL mode.
[SHIFT] [DEL] [EXE]	Clears the contents of the constant memories.
[AC] ON	Clears all formulas and values from the display. Clears any error messages, and turns power back on after activation of the auto power OFF function. Clears the contents of a specific user formula in the PCL mode.
[SHIFT] [AC]	Clears the contents of the statistical memories.

Key Operation	Application
×	Inputs multiplication sign.
SHIFT × ($\hat{x}$) EXE	Returns the estimated value of x in the LR mode.
ALPHA ln (CONST) × (ε_o)	Permittivity of vacuum (ϵo)
÷	Inputs division sign.
SHIFT ÷ ($\hat{y}$) EXE	Returns the estimated value of y in the LR mode.
ALPHA ln (CONST) ÷ (μo)	Permeability of vacuum (μo)
+	Inputs addition sign.
ALPHA ln (CONST) + (g)	Acceleration of free fall (g)
−	Inputs subtraction sign.
ALPHA ln (CONST) − (R)	Molar gas constant (R)
FMLA	Press following input of a number to recall the built-in formula which corresponds to the number, or press while a built-in formula is displayed to move to the next built-in formula.
SHIFT FMLA	Press while a built-in formula is displayed to move to the previous built-in formula.
EXE	Press to obtain the result of the currently displayed formula or calculation, or to input data.
SHIFT EXE (Ans)	Recalls the current contents of the answer memory.

Appendix B | What to Do When an Error Occurs

An error is generated when you make some mistake in operation of the calculator, or when you try to execute a user formula which is not written correctly. You will see a message appear on the display when an error occurs, something like the example illustrated below.



Press the ⇦ or ⇨ key to locate the error and make the required corrections. The steps you take to correct the situation depend on the type of error generated.

•Error Message Table

Message	Meaning	Countermeasures
Syn ERROR (Syntax Error)	Mistake in the format used for the formula.	Correct the mistake.
Ma ERROR (Mathematical Error)	•Calculation result is outside allowable range for the calculator. •Calculation is outside of the range allowed for a function being used. •Illegal mathematical operation (such as division by zero).	Check number value inputs to be sure they are within the allowable range. Be sure to check memory contents when memories are used in the calculation.
Stk ERROR (Stack Error)	Calculation exceeds the capacity of the numeric stack or the operation stack.	Simplify to keep calculations within eight levels for the numeric stack and 20 levels for the operation stack. Try breaking complex calculations down into two or more parts.
Mem ERROR (Memory Error)	More than 17 different variables used in a single formula.	Divide the formula so that each part has 16 or fewer variables.

Appendix C Technical Reference

This reference includes technical information concerning maximum input capacities, stacks, and specifications.

■ Order of Operations

This calculator uses true algebraic logic to perform calculations in the following sequence.

① Scientific functions which require input of a value preceding the function

x^2, x^{-1}, $x!$, $^\circ$, ^{r}, ^{g}, $^\square$, x^n

② Powers/roots

x^y, $\sqrt[x]{}$

③ Abbreviated multiplication format in front of pi, memory name, or parentheses.

2π, $4A$, etc.

④ Scientific functions which require input of a value after the function

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

⑤ Abbreviated multiplication format in front of scientific functions which require input of a value preceding the function

3sin5, $6\sqrt{}7$, 2sin30cos60, etc.

⑥ Multiplication and division

$\times$, $\div$

⑦ Addition and subtraction

$+$, $-$

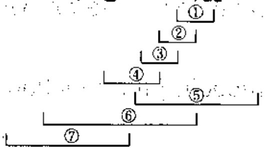
⑧ Logical AND

⑨ Logical OR and XOR

- Calculations which contain a series of operations which are of the same priority are performed from left to right.
- Compound functions are performed from right to left.
- Anything contained in parentheses receives highest priority.

Example

$2+3\times(\log \sin 2\pi^2{}_{rad}+6.8)=22.07101691$

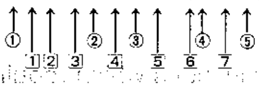


■ About Stacks

This calculator assigns a block of memory for stacks which temporarily store low priority numeric values and commands. The numeric stack has eight levels, while the operation stack has 20 levels. A Stk ERROR appears on the display whenever your calculation exceeds the capacity of one of the stacks.

Example

$2\times((3+4\times(5+4)\div3)\div5)+8=$



Numeric Stack

①	2
②	3
③	4
④	5
⑤	4
⋮	

Operation Stack

1	×
2	(
3	(
4	+
5	×
6	(
7	+
⋮	

• Note that calculations are performed according to the order of operations described above, and not according to their relative position in the stack. Once an operation is performed, it is cleared from the stack.

■ Maximum Value Sizes

You can enter values with up to 10 digits for the mantissa and 2 digits for the exponent. Internal intermediate results are handled with a mantissa up to 12 digits long, and a 2-digit exponent, but results are displayed in the 10-digit mantissa/2-digit exponent format. Calculation results of 10^{10} (10-billion) or greater or less than 10^{-2} (0.01) are automatically displayed in exponential form.

Example

123456789×9638=

123456789 ⊠ 9638 EXE | 1.189876532^{12}

Mantissa Exponent

■ Display Register

The display register stores the latest displayed value, and redisplays the value in a new format when the following commands are executed.

Mcl	Hex	Dec	Bin	Oct	Deg	Rad
Gra	Fix	Sci	Norm	Rnd	Scl	

This mades it easy to confirm that the above commands produce the desired result.

■ Number of Input Characters

This unit features a 79-step area for calculation.
One function comprises one step. Each press of numerals, ⊞, ⊟, ⊠, and ⊟ comprises one step. Though such operations as SHIFT e^x require two key operations, they actually comprise only one function and, therefore, only one step.
You can confirm these steps using the cursor. With each press of the ⇦ or ⇨ key the cursor is moved one step.
Input characters are limited to 79 steps. Usually the cursor is represented by a blinking "_", but once the 73rd step is reached the cursor changes to a blinking " ■ ". If the " ■ " appears during a calculation, the calculation should be divided at some point and performed in two parts.

■ How to Count User Formula Steps

The memory capacity of this calculator is counted in *formula steps*. You can input up to 675 formula steps in total for all of the user formulas to store. Each step is represented by all of the characters which appear on the display for a key operation, whether the key operation involves one key or more than one key. The following sample display illustrates a typical step count.

```
n=sin i/sin r_
①② ③  ④⑤ ⑥ ⑦
```

7th step

■ Input Ranges of Scientific Functions

Function name	Input range
$\sin x$, $\cos x$, $\tan x$	$\|x\| < 9000000000°$ (50000000π, 1×10^{10} gra)
$\sin^{-1} x$, $\cos^{-1} x$	$\|x\| \leqq 1$
$\tan^{-1} x$	$\|x\| < 10^{100}$
e^x	$-10^{100} < x \leqq 230.2585092$
$\sinh x$, $\cosh x$	$x \leqq 230.2585092$
$\tanh x$	$\|x\| < 10^{100}$
$\sinh^{-1} x$	$\|x\| < 5\times10^{99}$
$\cosh^{-1} x$	$1 \leqq x < 5\times10^{99}$
$\tanh^{-1} x$	$\|x\| < 1$
$\log x$, $\ln x$	$1\times10^{-99} \leqq x < 10^{100}$
10^x	$-10^{100} < x < 100$
$\sqrt{x}$	$0 \leqq x < 10^{100}$
x^2	$\|x\| < 10^{50}$
$x^{-1}\ (\frac{1}{x})$	$\|x\| < 10^{100}$, $x \neq 0$
$\sqrt[3]{x}$	$\|x\| < 10^{100}$
$x!$	$0 \leqq x \leqq 69$ (x=integer)

x^y	$x>0$: $-1\times10^{100}<y\log x<100$, $x=0$: $y>0$, $x<0$: $y=n$ or $\frac{1}{2n+1}$ (n=integer) $-1\times10^{100}<y\log\|x\|<100$
$\sqrt[x]{y}$ ($y^{\frac{1}{x}}$)	$y>0$: $x\neq0$, $-1\times10^{100}<\frac{1}{x}\log y<100$, $y=0$: $x>0$, $y<0$: $x=2n+1$ or $\frac{1}{n}$ ($n\neq0$, n=integer) $-1\times10^{100}<\frac{1}{x}\log\|y\|<100$
Binary	(+) $111111111\geqq x\geqq0$ (−) $1111111111\geqq x\geqq1000000000$
Octal	(+) $3777777777\geqq x\geqq0$ (−) $7777777777\geqq x\geqq4000000000$
Hexadecimal	(+) $7FFFFFFF\geqq x\geqq0$ (−) $FFFFFFFF\geqq x\geqq80000000$
Decimal→Sexagesimal	$\|x\|\leqq2777777.777$ Higher order digits given display priority for values exceeding 8 digits in length.
Statistical calculations	$\|x\|<10^{50}$, $\|y\|<10^{50}$, $\|n\|<10^{100}$

- Generally, precision for a result is ±1 at the 10th digit.
- Errors may be cumulative for sequential internal calculations with such functions as x^y, $x^{1/y}$, $x!$, $\sqrt[3]{x}$.
- In $\tan x$ $|x|\neq90°\times(2n+1)$, $|x|\neq\frac{\pi}{2}\text{rad}\times(2n+1)$, $|x|\neq100\text{gra}\ (2n+1)$. n = integer.
- Errors are cumulative with $\sinh x$ and $\tanh x$ when $x=0$.

■ Formulas Used for Statistical Calculations

The following formulas are used internally by the calculator for the operations noted.

•Standard Deviation

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

Using all data of a finite population to determine the standard deviation for the entire population.

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

Using sample data for a population to determine the standard deviation for the entire population.

•Mean

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

•Regression

Regression formula: $y = \mathrm{A} + \mathrm{B}x$

Constant term A and regression coefficient B are calculated using the following formulas.

Regression coefficient of regression formula

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

Constant term of regression formula

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

Estimated values $\hat{x}$ and $\hat{y}$ are calculated using the regression formula.

The correlation coefficient r for input data is calculated using the following formula.

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

Specifications

Computations

Basic computation functions: Negative numbers, exponents, parenthetical addition/subtraction/multiplication/division (with priority sequence judgement function — true algebraic logic).

Built-in functions: Trigonometric/inverse trigonometric functions (units of angular measurement: degrees, radians, grads), hyperbolic/inverse hyperbolic functions (fx-5000F), logarithmic/exponential functions, reciprocals, factorials, square roots, cube roots, powers, roots, squares, decimal-sexagesimal conversions, binary-octal-hexadecimal conversions/computations, π, random numbers, absolute values.

Statistical computation functions: Standard deviation — number of data, sum, sum of squares, mean, standard deviation (two types)
Linear regression — number of data, sum of x, sum of y, sum of squares of x, sum of squares of y, mean of x, mean of y, standard deviation of x (two types), standard deviation of y (two types), constant term, regression coefficient, correlation coefficient, estimated value of x, estimated value of y.

Number of built-in formulas: 128

Memories: Formula — 16
Constant — 10

Computation range: $\pm 1 \times 10^{-99} \sim \pm 9.999999999 \times 10^{99}$ and 0.
Internal operation uses 12-digit mantissa.

Rounding: Performed according to the specified number of significant digits or the number of specified decimal places.

Formula memory

Number of steps: 675

Number of stored formulas: 12 maximum (P0 to PB)

Check function: Formula checking, debugging, deletion, addition, etc.

Common section

Display system and contents: 2 line liquid crystal display (upper line: 14-digit dot matrix display, lower line: 2-digit dot matrix display and 10-digit mantissa plus 2-digit exponent), binary, octal, hexadecimal display, sexagesimal display, condition displays (WRT, PCL, Disp, LR, SD, D, R, G, S, M, A, x^n, hyp, d, h, b, o, Fix, Sci)

Error check function: Checks for values exceeding 10^{100} and illogical computations; error messages displayed.

Power supply: Two lithium batteries (CR2032)

Power comsumption: 0.008W

Battery life: Approximately 790 hours on type CR2032.

Auto power off: Power is automatically switched off approximately 6 minutes after last operation.

Ambient temperature range: 0°C ~ 40°C (32°F ~ 104°F)

Dimensions: fx-1000F: 16.5mmH × 72mmW × 131mmD
($^5/_8$"H × 2$^7/_8$"W × 5$^1/_8$"D)
fx-5000F: 9.2mmH × 72mmW × 131mmD
($^3/_8$"H × 2$^7/_8$"W × 5$^1/_8$"D)

Weight: fx-1000F: 99g (3.5oz) including batteries
fx-5000F: 93g (3.3oz) including batteries