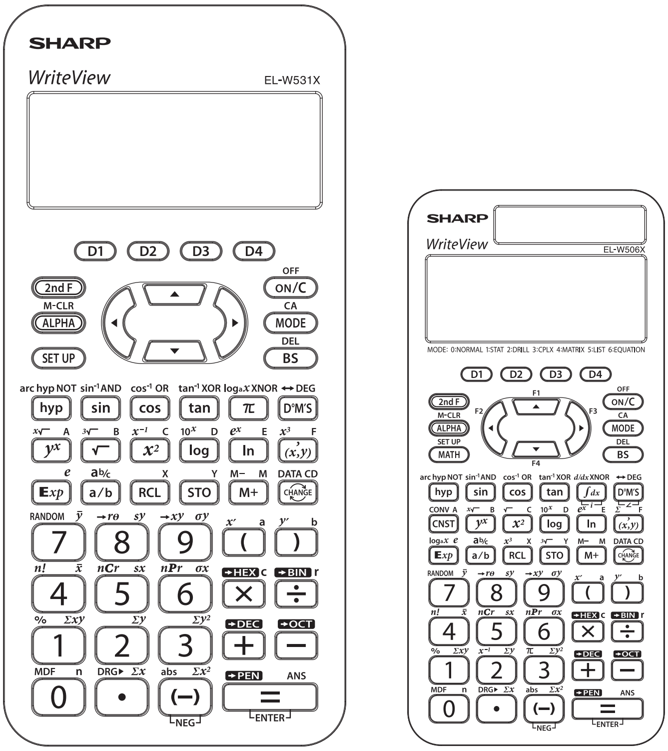
Scientific Calculator Operation Guide

<Write View>



- If you are accessing from **Europe**, please visit:
  http://www.sharp-calculators.com/
  You can get the Guide book of the latest model.
- If you are accessing from **U.S.A.**, please visit:
  https://sharpcalculators.com/
  You can get the Guide book of the latest model.

SHARP

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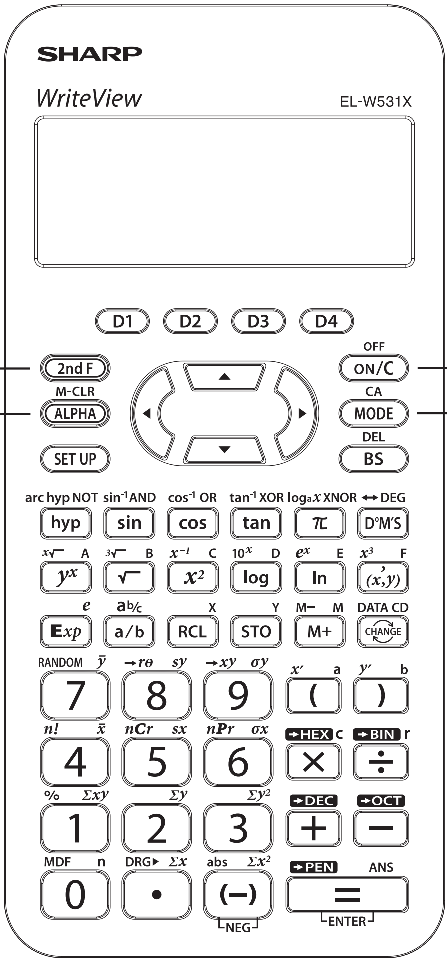
How to Operate

≈Read Before Using≈

This operation guide has been written based on the EL-W531X, EL-W535X, EL-W531XH, EL-W531XG, EL-W531, EL-W506X, EL-W516X and EL-W506 models. Some functions described here are not featured on other models.
In addition, key operations and symbols on the display may differ according to the model.

1. KEY LAYOUT



2nd function, ALPHA keys

Pressing these keys will enable the functions written in orange (2nd F) or green (ALPHA) above the calculator buttons.

2nd function

[2nd F] [OFF] Written in orange above the ON/C key

<Power off>

ON/C, OFF key

Direct function

[ON/C]

<Power on>

[MATH] (EL-W506X/EL-W516X/EL-W506 only)

Mode key

This calculator can operate in three different modes as follows.

<Example>

[Normal mode] [MODE] [0]

•Mode = 0; normal mode for performing normal arithmetic and function calculations.

[STAT mode] [MODE] [1]

•Mode = 1; mode for performing 1- or 2-variable statistical calculations. To select the statistical sub-mode, press the corresponding number key after [MODE] [1].

[0] (SD): Single variable statistic calculation

[1] (LINE): Linear regression calculation

[2] (QUAD): Quadratic regression calculation

[3] (E_EXP): Eular Exponential regression calculation

[4] (LOG): Logarithmic regression calculation

[5] (POWER): Power regression calculation

[6] (INV): Inverse regression calculation

[7] (EXP): Exponential regression calculation

[Drill mode] [MODE] [2]

•Mode = 2; mode for performing drill calculations. To select the drill sub-mode, press the corresponding number key after [MODE] [2].

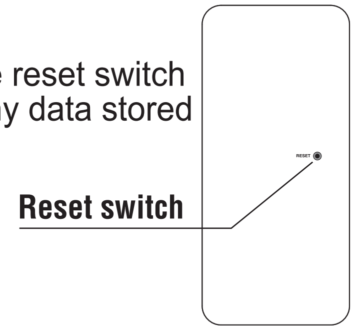
[0] (MATH): Math drill

[1] (TABLE): Multiplication table drill

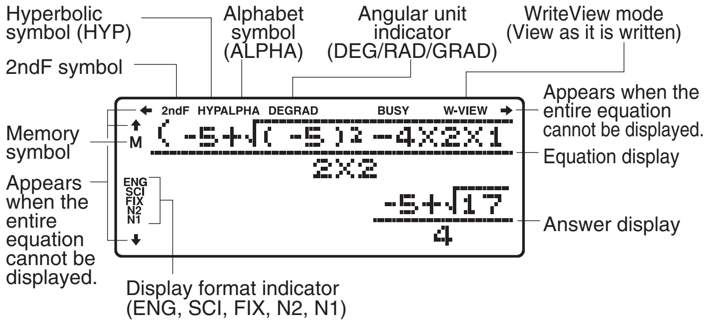
2. RESET SWITCH RESET

If the calculator fails to operate normally, press the reset switch on the back to reinitialise the unit. The display format and calculation mode will return to their initial settings.

NOTE:
Pressing the reset switch will erase any data stored in memory.



3. DISPLAY PATTERN



The actual display does not appear like this. This illustration is for explanatory purposes only.

4. DISPLAY FORMAT AND DECIMAL SETTING FUNCTION

For convenient and easy operation, this model can be used in one of five display modes. The selected display status is shown in the lower left part of the display (Format Indicator).
Note: If more 0's (zeros) than needed are displayed when the ON/C key is pressed, check whether or not the calculator is set to a Special Display Format.

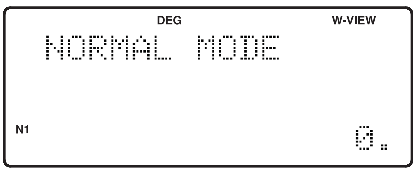
- Floating decimal point format 1/2 (N1/N2 is displayed)
  Valid values beyond the maximum range are displayed in the form of [10-digit (mantissa) + 2-digit (exponent)]
- Fixed decimal point format (FIX is displayed)
  Displays the fractional part of the calculation result according to the specified number of decimal places.
- Scientific notation (SCI is displayed)
  Frequently used in science to handle extremely small or large numbers.
- Engineering scientific notation (ENG is displayed)
  Convenient for converting between different units.

<Example> Let's compare the display result of [10000 ÷ 8.1 =] in each display format.

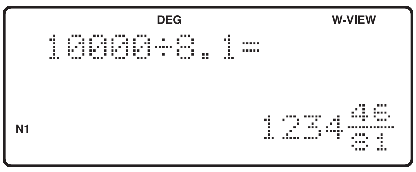
(specifies normal mode)

Note: The calculator has two settings for displaying a floating point number: NORM1 (default setting) and NORM2. In each display setting, a number is automatically displayed in scientific notation outside a preset range:
- NORM1: 0.000000001 ≤ x ≤ 9999999999
- NORM2: 0.01 ≤ x ≤ 9999999999

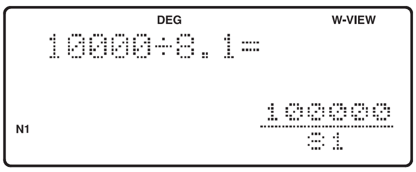
Initial display



10000 [÷] **8.1** [=]



[CHANGE]



[CHANGE]

DEG W-VIEW
10000÷8.1=
N1 1'234.567901

[SET UP] [1] [0] [3]

DEG W-VIEW
10000÷8.1=
FIX 1'234.568

(FIX mode TAB = 3)

[SET UP] [1] [1] [3]

DEG W-VIEW
10000÷8.1=
SCI 1.23E03

(SCI mode)

[SET UP] [1] [2] [3]

DEG W-VIEW
10000÷8.1=
ENG 1.235E03

(ENG mode)

[SET UP] [1] [3]

DEG W-VIEW
10000÷8.1=
N1 1'234.567901

(normal mode)

5. EXPONENT DISPLAY

The distance from the earth to the sun is approx. 150,000,000 (1.5×10^8) km. Values such as this with many zeros are often used in scientific calculations, but entering the zeros one by one is a great deal of work and it's easy to make mistakes. In such cases, the numerical values are divided into mantissa and exponent portions, displayed and calculated.

<Example> What is the number of electrons flowing in a conductor when the electrical charge across a given cross-section is 0.32 coulombs. (The charge on a single electron = 1.6×10^{-19} coulombs).

0.32 [÷] 1.6 [Exp] 19 [=]

DEG W-VIEW
0.32÷1.6E19=
N1 2.E-20

6. ANGULAR UNIT

Angular values are converted from DEG to RAD to GRAD with each push of the DRG key. This function is used when doing calculations related to trigonometric functions or coordinate geometry conversions.

Degrees (DEG is shown at the top of the display)

A commonly used unit of measure for angles. The angular measure of a circle is expressed as 360°.

Radians (RAD is shown at the top of the display)

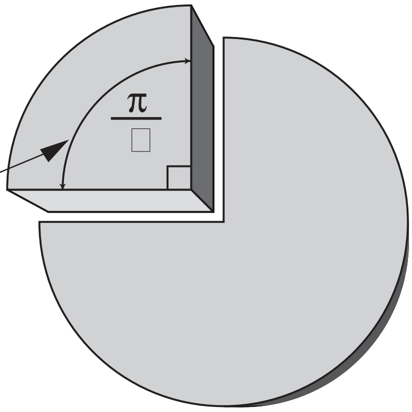
Radians are different from degrees and express angles based on the circumference of a circle. 180° is equivalent to π radians. Therefore, the angular measure of a circle is 2π radians.

Grads (GRAD is shown at the top of the display)

Grads are a unit of angular measure used in Europe, particularly in France. An angle of 90 degrees is equivalent to 100 grads.

The relationships between the three types of angular units can be expressed as right:

90° (DEG) =
π/2 (RAD) =
100 (GRAD) =

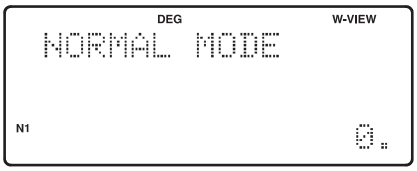


<Example> Check to confirm 90 degrees equalling π/2 radians equalling 100 grads. (π=3.14159...)

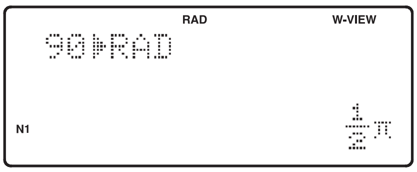
Operation

Display

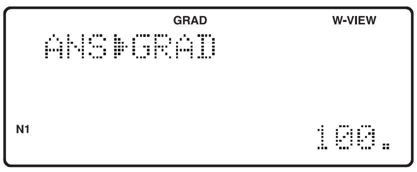
SET UP 0 0



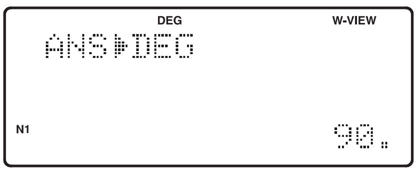
90 2ndF DRG▶



2ndF DRG▶



2ndF DRG▶



ON/OFF, Entry Correction Keys [ON/C] [OFF] [CA] [▲] [▼] [◀] [▶] [BS] [DEL]

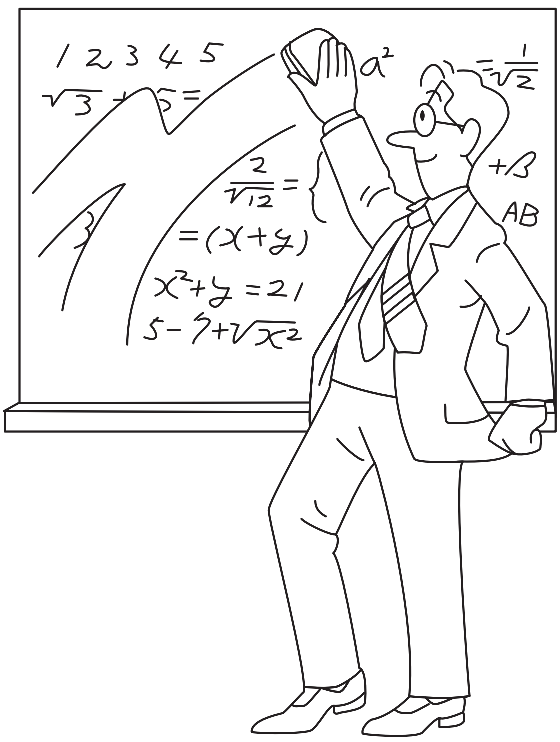
[ON/C] Turns the calculator on or clears the data. It also clears the contents of the calculator display and voids any calculator command; however, coefficients in 3-variable linear equations and statistics, as well as values stored in the independent memory in normal mode, are not erased.

[OFF] Turns the calculator off.

[CA] Clears all internal values, including the last answer (ANS) and statistics. Values stored in memory in normal mode are not erased.

[▲] [▼] These arrow keys are useful for Multi-Line playback, which lets you scroll through calculation steps one by one.

[◀] [▶] [BS] [DEL] These keys are useful for editing equations. The [◀] key moves the cursor to the left, and the [▶] key moves the cursor to the right. The [BS] key deletes the symbol/number at the left of the cursor, and the [DEL] key deletes the symbol/number at the cursor.



Data Entry Keys [•] [(−) NEG] [π] [π] [Exp]

0 to 9 Numeric keys for entering data values.

[•] Decimal point key. Enters a decimal point.

[(−) NEG] Enters the minus symbol.
The subtraction key [−] is not used for entering negative numbers.

[π] Pressing π automatically enters the value for π (3.14159...).
The constant π, used frequently in function calculations, is the ratio of the circumference of a circle to its diameter
([π] EL-W506X/EL-W516X/EL-W506 only)

[Exp] Pressing this key switches to scientific notation data entry.

<Example> Provided the earth is moving around the sun in a circular orbit, how many kilometers will it travel in a year?

* The average distance between the earth and the sun being 1.496×10^8 km.

Circumference equals diameter x π; therefore,
$1.496 \times 10^8 \times 2 \times \pi$

Operation	Display
1.496 [Exp] 8 [×] 2 [×] [π] [=]	DEG W-VIEW 1.496E8×2×π= N1 939'964'522.

Random Key RANDOM

RANDOM Generates random numbers.
Random numbers are three-decimal-place values between 0.000 and 0.999. Using this function enables the user to obtain unbiased sampling data derived from random values generated by the calculator. (Using line mode is preferable since in W-View mode, the numbers are generated by fractions.)

<Example>

2ndF RANDOM 0 = 0. * * * (A random number is generated.)

[Random Dice]
To simulate a die-rolling, a random integer between 1 and 6 can be generated by pressing 2ndF RANDOM 1 ENTER. To generate the next random dice number, press ENTER.

[Random Coin]
To simulate a coin flip, 0 (heads) or 1 (tails) can be randomly generated by pressing 2ndF RANDOM 2 ENTER. To generate the next random coin number, press ENTER.

[Random Integer]
An integer between 0 and 99 can be generated randomly by pressing 2ndF RANDOM 3 ENTER. To generate the next random integer, press ENTER.

APPLICATIONS:
Building sample sets for statistics or research.

Modify Key MDF

MDF Function to round calculation results.

Even after setting the number of decimal places on the display, the calculator performs calculations using a larger number of decimal places than that which appears on the display. By using this function, internal calculations will be performed using only the displayed value.

<Example> **FIX mode TAB = 1 (normal calculation)**

5 [÷] 9 [=] **0.6** (internally, 0.5555...)

[×] 9 [=] **5.0**

Rounded calculation (MDF)

5 [÷] 9 [=] **0.6** (internally, 0.5555...)

(In W-View mode, pres [CHANGE] to show the answer in decimal.)

[2ndF] [MDF] (internally, 0.6)

[×] 9 [=] **5.4**

APPLICATIONS:
Frequently used in scientific and technical fields, as well as business, when performing chained calculations.

Basic Arithmetic Keys, Parentheses [+] [−] [×] [÷] [=] [(] [)]

[+] [−] [×] [÷] The four basic operators. Each is used in the same way as a standard calculator:
+ (addition), – (subtraction), x (multiplication), and ÷ (division).

[=] Finds the result in the same way as a standard calculator.

[(] [)] Used to specify calculations in which certain operations have precedence. You can make addition and subtraction operations have precedence over multiplication and division by enclosing them in parentheses.

Percent [%]

[%] For calculating percentages. Four methods of calculating percentages are presented as follows.

1) $125 increased by 10%…137.5

125 [+] 10 [2ndF] [%]

DEG W-VIEW
125+10%
N1 137 1/2

[CHANGE]

DEG W-VIEW
125+10%
N1 275/2

[CHANGE]

DEG W-VIEW
125+10%
N1 137.5

2) $125 reduced by 20%…100

125 [−] 20 [2ndF] [%]

DEG W-VIEW
125−20%
N1 100.

3) 15% of $125…18.75

125 [×] 15 [2ndF] [%]

DEG W-VIEW
125×15%
N1 18 3/4

4) When $125 equals 5% of X, X equals…2500

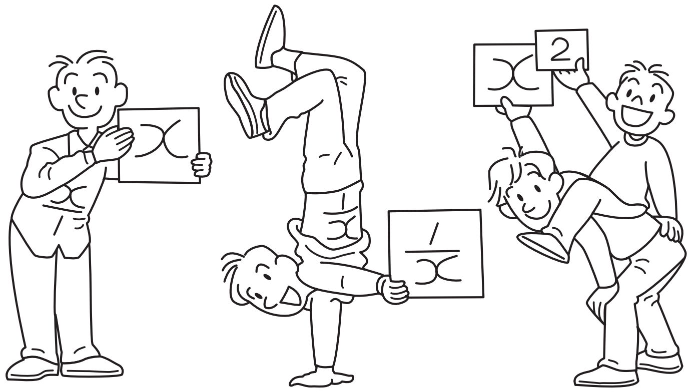
125 [÷] 5 [2ndF] [%]

DEG W-VIEW
125÷5%
N1 2'500.

Inverse, Square, Cube, xth Power of y, Square Root, Cube Root, xth Root of y

[x^{-1}] [x^2] [x^3] [y^x] [$\sqrt{\ }$] [$\sqrt[3]{\ }$] [$\sqrt[x]{\ }$]

[x^{-1}]	Calculates the inverse of the value on the display.
[x^2]	Squares the value on the display.
[x^3]	Cubes the value on the display.
[y^x]	Calculates exponential values.
[$\sqrt{\ }$]	Calculates the square root of the value on the display.
[$\sqrt[3]{\ }$]	Calculates the cube root of the value on the display.
[$\sqrt[x]{\ }$]	Calculates the x^{th} root of y.



<Example>

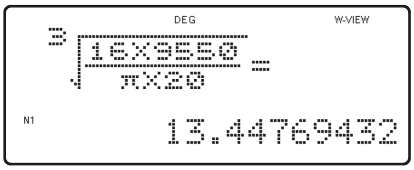
Operation	Display
2 [×] 2 [×] 2 [×] 2 [=]	DEG W-VIEW 2×2×2×2= N1 16.
2 [y^x] 4 [=]	DEG W-VIEW 2^4= N1 16.
4 [2ndF] [$\sqrt[x]{\ }$] 16 [=]	DEG W-VIEW $\sqrt[4]{16}$= N1 2.

Power and Radical root [$\sqrt[3]{\ }$]

<Example 1> Design a shaft that bears a torque *T* (= 9,550 Nm).
τ is a constant that is determined by the material of the shaft, and is taken to be τ = 20 N/mm^2.

$$d = \sqrt[3]{\frac{16T}{\pi\tau}}$$

(Function for EL-W506X/EL-W516X/EL-W506)

Operation	Display
[ON/C] [2ndF] [$\sqrt[3]{\ }$] [a/b]	
16 [×] 9550 [▶] [2ndF]	
[π] [×] 20 [=]	

(Function for EL-W531X/EL-W535X/EL-W531XH/EL-W531XG/EL-W531)

Use [π] instead of [2ndF] [π].

Power and Radical root [y^x] [$\sqrt[x]{\ }$]

<Example 2> If the principal is a (¥), the annual interest rate is *r* (%), and the number of years of interest accumulation is *x* (years), the final amount *y* (¥) is given by the following equation:

$$y = a(1 + r/100)^x$$

(1) Find the final amount when a principal of ¥400,000 is deposited for three years at an annual interest rate of 5% and the interest is compounded annually.

$$y = 400000\left(1 + \frac{5}{100}\right)^3$$

(2) When a principal of ¥300,000 is deposited for five years and the interest is compounded annually, the final amount is ¥339,422. The annual interest rate *r* is given by the equation below. Find the annual interest rate *r*.

$$r = 100\left(\sqrt[x]{\frac{y}{a}} - 1\right)$$

$$r = 100\left(\sqrt[5]{\frac{339422}{300000}} - 1\right)$$

Operation	Display
(1)	
[ON/C] 400000 [(] 1 [+]	
[a/b] 5 [▶] 100 [▶]	DEG W-VIEW $400000\left(1+\frac{5}{100}\right)^3=$ N1 463'050.
[)] [y^x] 3 [=]	
(2)	
[ON/C] 100 [(] [2ndF]	
[$\sqrt[x]{\ }$] 5 [▶] [a/b] 339422	
[▶] 300000 [▶] [▶]	DEG W-VIEW $100\left(\sqrt[5]{\frac{339422}{300000}}-1\right)=$ N1 2.499971984
[−] 1 [)] [=]	

Power and Radical root [y^x] [$\sqrt[x]{\ }$]

<Example 3> The musical note A is 440 Hz.
Calculate the frequencies of the notes in (1) to (3).

(1) "C" of A, A# (B♭), B, C

$$400 \times (\sqrt[12]{2})^3$$

(2) "C" of A, G, F, E, D, C

$$\frac{400 \times (\sqrt[12]{2})^3}{2}$$

(3) "A" one octave higher

$$400 \times (\sqrt[12]{2})^{12}$$

Operation	Display
(1)	
[ON/C] 440 [×] [(]	
[2ndF] [$\sqrt[x]{\ }$] 12 [▶] 2	DEG W-VIEW $440\times(\sqrt[12]{2})^3=$
[▶] [)] [y^x] 3 [=]	N1 523.2511306
(2)	
[ON/C] [a/b] 440 [×]	
[(] [2ndF] [$\sqrt[x]{\ }$] 12	
[▶] 2 [▶] [)]	
[y^x] 3 [▶] [▶] 2	DEG W-VIEW $\frac{440\times(\sqrt[12]{2})^3}{2}=$
[=]	N1 261.6255653
(3)	
[ON/C] 440 [×] [(]	
[2ndF] [$\sqrt[x]{\ }$] 12 [▶] 2	DEG W-VIEW $440\times(\sqrt[12]{2})^{12}=$
[▶] [)] [y^x] 12 [=]	N1 880.

10 to the Power of x, Common Logarithm, Logarithm of x to Base a [10^x] [log] [$\log_a x$]

[10^x]	Calculates the value of 10 raised to the x^{th} power.
[log]	Calculates the logarithm, the exponent of the power to which 10 must be raised to equal the given value.
[$\log_a x$]	Calculates the logarithm of *x* to power a.

<Example>

Operation	Display
[2ndF] [10^x] 3 [=]	DEG W-VIEW 10^3= N1 1'000.
[log] 1000 [=]	DEG W-VIEW log1000= N1 3.
[2ndF] [$\log_a x$] 3 [▶] 45 [=]	DEG W-VIEW $\log_3$(45)= N1 3.464973521

Exponential, Logarithmic [10^x] [log]

<Example 1> If E (units: joules) is the amount of energy released by an earthquake and M is the magnitude, the relation

$$\log E = 4.8 + 1.5M$$

holds.

If E' is the energy when the magnitude increases by N,

$$\frac{E'}{E} = 10^{1.5N}$$

holds.

(1) When the magnitude increases by 1, by what factor does the energy increase?

(2) When the magnitude increases by 2, by what factor does the energy increase?

(3) The amount of energy in 20,000 tons of TNT is 8×10^{13} joules. When this energy is converted to a magnitude,

$$M = \frac{\log E - 4.8}{1.5}$$

holds. Find the magnitude M.

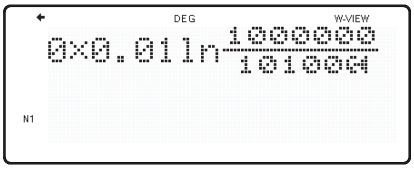
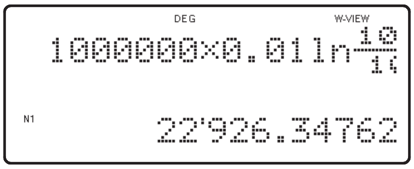
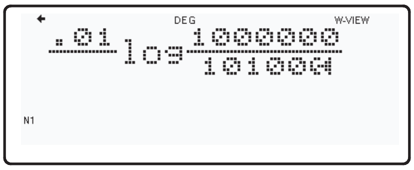
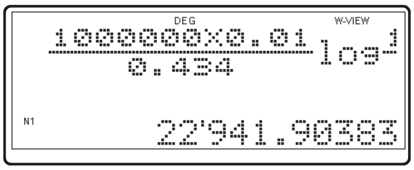
	Operation	Display
(1)	[ON/C] [2ndF] [10^x] 1.5 [×] 1 [=]	10^1.5×1 = 31.6227766
(2)	[ON/C] [2ndF] [10^x] 1.5 [×] 2 [=]	10^1.5×2 = 1'000.
(3)	[ON/C] [a/b] [log] [(] 8 [×] [2ndF] [10^x] 13 [▶] [)] [−] 4.8 [▶] 1.5 [=]	(log(8×10^13)−4.8) / 1.5 = 6.068726658

Exponential, Logarithmic [ln] [log]

<Example 2> Air is held inside a cylinder of volume V_1 (= 0.01 m^3) at a pressure P_1 (= 1,000,000 Pa) at 27°C with a piston.
Find the quantity of thermal energy Q needed to expand the air at constant temperature to a pressure of P_2 (= 101,000 Pa).

$$Q = p_1 V_1 \ln \frac{p_1}{p_2}$$

$$\approx \frac{p_1 V_1}{0.434} \log \frac{p_1}{p_2}$$

Operation	Display
[ON/C] 1000000 [×] 0.01 [ln] [a/b] 1000000 [▶] 101000 [=]	 
[ON/C] [a/b] 1000000 [×] 0.01 [▶] 0.434 [▶] [log] [a/b] 1000000 [▶] 101000 [=]	 

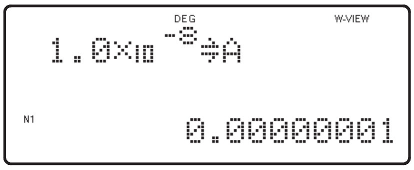
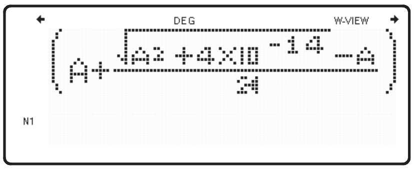
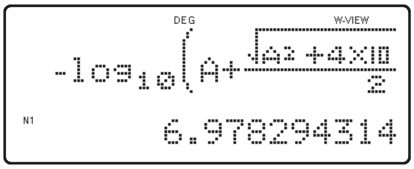
Exponential, Logarithmic

[10^x] [(−)] [STO] [A] [$\log_a x$] [√] [x^2]

<Example 3> Find the pH of hydrochloric acid HCl at a concentration of 1.0×10^{-8} mol/L
* pH = 7 (neutral), pH < 7 (acidic), pH > 7 (alkaline)

$$\mathrm{pH} = -\log_{10}\left(a + \frac{\sqrt{a^2+4\times10^{-14}} - a}{2}\right)$$

(Function for EL-W506X/EL-W516X/EL-W506)

Operation	Display
Enter the value of *a*	
[ON/C] 1.0 [×] [2ndF] [10^x] [(−) NEG] 8 [STO] [A]	
Calculate the pH	
[(−) NEG] [2ndF] [$\log_a x$] 10 [▶] [ALPHA] [A] [+] [a/b] [2ndF] [√] [ALPHA] [A] [x^2] [+] 4 [×] [2ndF] [10^x] [(−) NEG]	
14 [▶] [▶] [−] [ALPHA] [A] [▶] 2 [=]	

(Function for EL-W531X/EL-W535X/EL-W531XH/EL-W531XG/EL-W531)

Use [√] instead of [2ndF] [√].

e to the Power of x, Natural Logarithm e^x ln

e^x Calculates powers based on the constant e (2.718281828).

ln Computes the value of the natural logarithm, the exponent of the power to which e must be raised to equal the given value.

<Example>

Operation	Display
2ndF e^x 5 =	DEG W-VIEW e^5= N1 148.4131591
ln 10 =	DEG W-VIEW ln10= N1 2.302585093

Factorials [n!]

[n!] The product of a given positive integer *n* multiplied by all the lesser positive integers from 1 to *n*-1 is indicated by *n*! and called the factorial of *n*.

<Example 1>

Operation	Display
7 [2nd F] [n!] [=]	DEG W-VIEW 7!= N1 5'040.

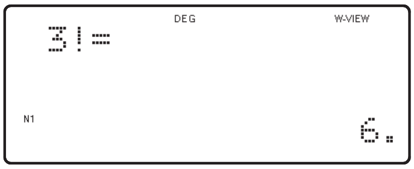
c.f
n! = 1 x 2 x 3 x …x*n*

APPLICATIONS:
Used in statistics and mathematics. In statistics, this function is used in calculations involving combinations and permutations.

Factorials n!

<Example 2> How many arrangements exist of cards of three colors: red, blue, and yellow?

3! = 3 x 2 x 1 = 6

Operation	Display
ON/C 3 2ndF n! =	

Permutations, Combinations [nPr] [n!] [nCr]

<Example 1> (1) When three cards are selected from five cards numbered 1 to 5 and placed in a row, how many possible orderings of the cards are there?

$${}_5P_3 = 5 \times 4 \times 3$$

(2) When three cards are selected from five cards numbered 1 to 5, how many ways of selecting the cards are possible?

Let the number of ways of selecting the cards be *C*. There are 3! possible orderings of the cards, and thus when ordered in a row

$$C \times 3! = {}_5P_3$$

Therefore *C* is

$$C = {}_5P_3 \div 3!$$

*This is written as ${}_5C_3$.

Operation	Display
(1)	
[ON/C] 5 [2ndF] [nPr] 3 [=]	DEG W-VIEW 5P3= N1 60.
(2)	
[ON/C] 5 [2ndF] [nPr] 3 [÷] 3 [2ndF] [n!] [=]	DEG W-VIEW 5P3÷3!= N1 10.
[ON/C] 5 [2ndF] [nCr] 3 [=]	DEG W-VIEW 5C3= N1 10.

Permutations, Combinations [nCr] [x³]

<Example 2> Find the probability of drawing one pair when 5 cards are drawn from a deck of 52 cards.
No jokers are included in the deck.

Probability of drawing one pair =
Ways of selecting one pair ÷ Ways of selecting 5 cards

Ways of selecting one pair =
Ways of selecting two cards to make a pair x Ways of selecting 3 remaining cards

Ways of selecting two cards to make a pair
Ways of selecting the number: 13 possibilities from 1 to 13 (King)
Ways of selecting the suit: Two suits selected from four, ${}_4C_2$
Hence

$13 \times {}_4C_2$

Ways of selecting remaining three cards
Ways of selecting the number: Three types are selected from (13 - 1) types ${}_{(13-1)}C_3$

Ways of selecting the suit: For each number on the three cards, there are 4 types of suit 4^3
Hence

${}_{12}C_3 \times 4^3$

Ways of selecting five cards

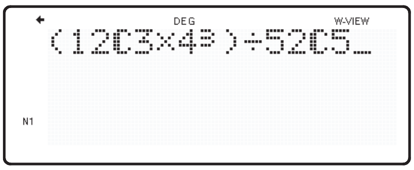
${}_{52}C_5$

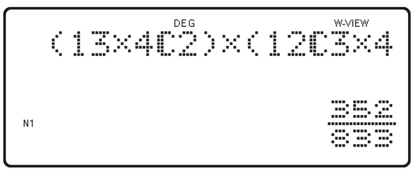
The probability of drawing one pair is
$(13 \times {}_4C_2) \times ({}_{12}C_3 \times 4^3) \div {}_{52}C_5$

Operation

[ON/C] [(] 13 [×] 4
[2ndF] [nCr] 2 [)]
[×] [(] 12 [2ndF]
[nCr] 3 [×] 4
[2ndF] [x³] [)] [÷]
52 [2ndF] [nCr] 5
[=]

Display





Permutations, Combinations nPr nCr

nPr This function finds the number of different possible orderings in selecting *r* objects from a set of *n* objects. For example, there are six different ways of ordering the letters ABC in groups of three letters—ABC, ACB, BAC, BCA, CAB, and CBA.
The calculation equation is ${}_3P_3 = 3 \times 2 \times 1 = 6$ (ways).

nCr This function finds the number of ways of selecting *r* objects from a set of *n* objects. For example, from the three letters ABC, there are three ways we can extract groups of two different letters—AB, AC, and CB.
The calculation equation is ${}_3C_2$.

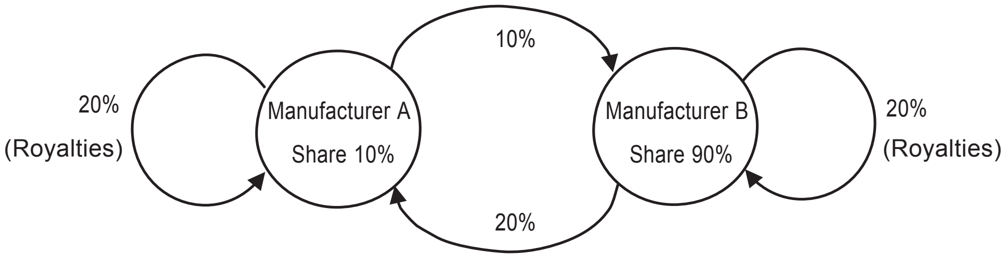
<Example>

Operation	Display
6 [2ndF] [nPr] 4 [=]	DEG W-VIEW 6P4= N1 360.
6 [2ndF] [nCr] 4 [=]	DEG W-VIEW 6C4= N1 15.

APPLICATIONS:
Used in statistics (probability calculations) and in simulation hypotheses in fields such as medicine, pharmaceutics, and physics. Also, can be used to determine the chances of winning in lotteries.

Matrix Calculation MODE MATH x^2 x^3

In a certain year (year 0), the share of manufacturer A is 10% and the share of manufacturer B is 90%. Manufacturer A then releases a new product, and each following year it maintains 90% of the share a_k it had the previous year (year k), and usurps 20% of the share b_k of manufacturer B.
Find the transition matrix for this process and the shares of manufacturers A and B after 5 years.



Answer

The share of each company after one year is expressed as follows using a_0 and b_0.

$a_1 = 0.9a_0 + 0.2b_0$
$b_1 = (1\text{-}0.9)a_0 + (1\text{-}0.2)b_0$

Thus, a_1 and b_1 are

$a_2 = 0.9a_1 + 0.2b_1$
$b_2 = 0.1a_1 + 0.8b_1$

The transition matrix is

$$A = \begin{bmatrix} 0.9 & 0.2 \\ 0.1 & 0.8 \end{bmatrix}$$

In the same way, after two years

$a_2 = 0.9a_1 + 0.2b_1$
$b_2 = 0.1a_1 + 0.8b_1$

Expressing a_2 and b_2 using a_0 and b_0 gives

$a_2 = 0.9(0.9a_0 + 0.2b_0) + 0.2(0.1a_0 + 0.8b_0)$
$= (0.9 \times 0.9 + 0.2 \times 0.1)a_0 + (0.9 \times 0.2 + 0.2 \times 0.8)b_0$
$= 0.83a_0 + 0.34b_0$
$b_2 = 0.1(0.9a_0 + 0.2b_0) + 0.8(0.1a_0 + 0.8b_0)$
$= (0.1 \times 0.9 + 0.8 \times 0.1)a_0 + (0.1 \times 0.2 + 0.8 \times 0.8)b_0$
$= 0.17a_0 + 0.66b_0$

In summary,

$a_2 = 0.83a_0 + 0.34b_0$
$b_2 = 0.17a_0 + 0.66b_0$

$A^2 = \begin{bmatrix} 0.83 & 0.34 \\ 0.17 & 0.66 \end{bmatrix}$: This is equal to matA^2. (Refer to Example 1)

Finding a_3 and b_3 in the same way,

$$a_3 = 0.781a_0 + 0.438b_0$$
$$b_3 = 0.219a_0 + 0.562b_0$$

Expressing the coefficients as a matrix gives

$$A^3 = \begin{bmatrix} 0.781 & 0.438 \\ 0.219 & 0.562 \end{bmatrix}$$: This is equal to matA^3. (Refer to Example 1)

From the above, the coefficients of the calculation formula of each company's share after 5 years can be found by repeated application of matrix A.

After 5 years: $C = A^5 = A^2 \times A^3$ (Refer to Example 2 - 1)

The shares of manufacturers A and B after 5 years and 10 years are

$$a_2 = 0.72269a_0 + 0.55462b_0 = 57\ \%$$
$$b_2 = 0.27731a_0 + 0.44538b_0 = 43\ \%$$
(Refer to Example 2 - 2)

Matrix Calculation MODE MATH x^2 x^3

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 1>

Let

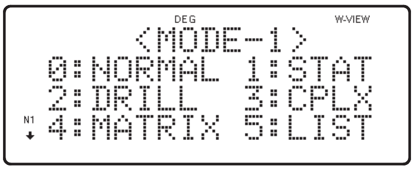
$$\text{matA} = \begin{bmatrix} 0.9 & 0.2 \\ 0.1 & 0.8 \end{bmatrix}$$

Find matA^2 and matA^3

Operation	**Display**

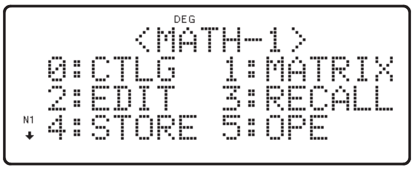
Set the mode to Matrix

MODE **4 (MATRIX)** Matrix mode



Enter matA

MATH **2 (EDIT)**



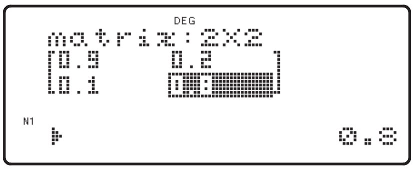
ENTER

<2 x 2 Matrix>

0.9 **ENTER** **0.2** **ENTER**

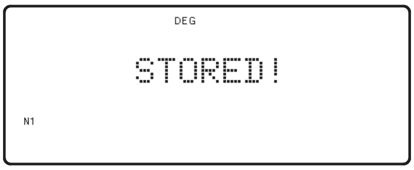
0.1 **ENTER** **0.8** **ENTER**

<Enter numeric values>



ON/C **MATH** **4 (STORE) 0**

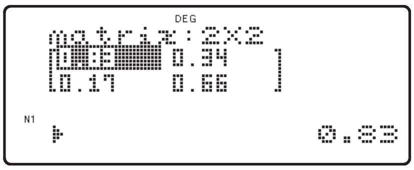
<0: Save to matA>



Calculate

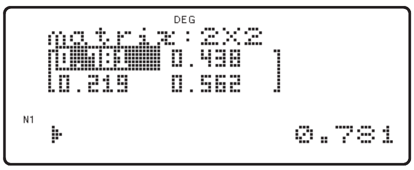
ON/C **MATH** **1 (MATRIX) 0**

x^2 **=** <Calculate the square>



ON/C **MATH** **1 (MATRIX) 0**

2ndF **x^3** **=** <Calculate the cube>



Matrix Calculation MODE MATH

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>

Let

$$\text{matB} = \begin{bmatrix} 0.83 & 0.34 \\ 0.17 & 0.66 \end{bmatrix} \qquad \text{matC} = \begin{bmatrix} 0.781 & 0.438 \\ 0.219 & 0.562 \end{bmatrix}$$

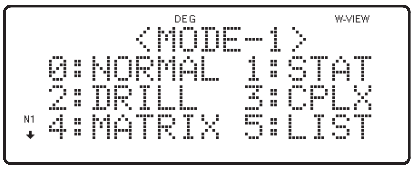
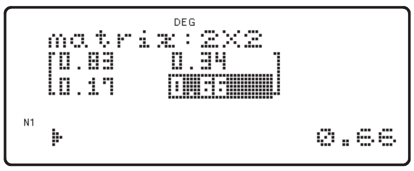
(1) Find matB x matC.

(2) The calculation result of (1) is

$$\text{matD} = \begin{bmatrix} c & d \\ e & f \end{bmatrix}$$

Letting $a_0 = 10$, $b_0 = 90$,
Calculate

$$a_5 = ca_0 + db_0$$
$$b_5 = ea_0 + fb_0$$

Operation	Display
Set the mode to Matrix MODE **4 (MATRIX)** Matrix mode	
Enter matB MATH **2 (EDIT)** **2 2** ENTER <2 x 2 Matrix> **0.83** ENTER **0.34** ENTER **0.17** ENTER **0.66** ENTER <Enter numeric values>	
ON/C MATH **4 (STORE) 1** <1: Save to matB>	

Matrix Calculation MODE MATH

Enter matC

MATH **2 (EDIT)**

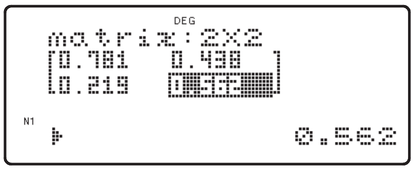
2 2 ENTER

<2 x 2 Matrix>

0.781 ENTER **0.438** ENTER

0.219 ENTER **0.562** ENTER

<Enter numeric values>



ON/C MATH **4 (STORE) 2**

<2: Save to matC>

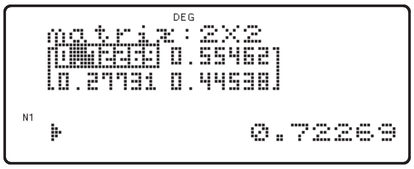
3. Calculate
   (1)

ON/C MATH **1 (MATRIX)**

1 ×

MATH **1 (MATRIX) 2**

=



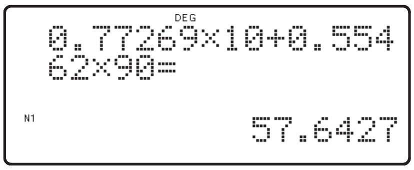
(2)

ON/C

0.77269 × **10** +

0.55462 × **90** =

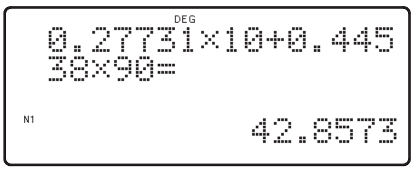
57.6427



0.27731 × **10** +

0.44538 × **90** =

42.8573

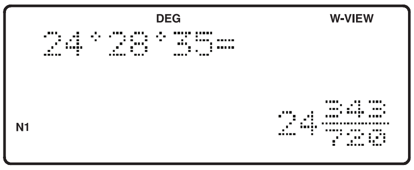
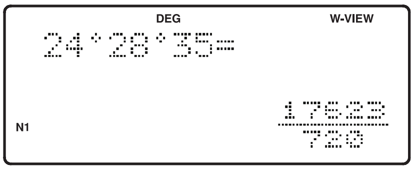
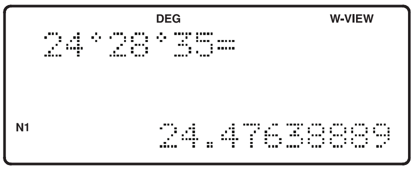
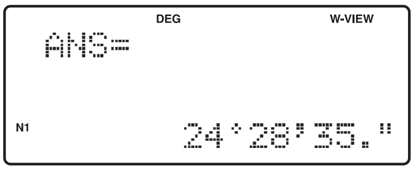


Time Calculation [↔DEG] [D°M′S]

[↔DEG] Converts a sexagesimal value displayed in degrees, minutes, seconds to decimal notation. Also, converts a decimal value to sexagesimal notataion (degrees, minutes, seconds).

[D°M′S] Inputs values in sexagesimal notation (degrees, minutes, seconds).

<Example> Convert 24° 28’ 35” (24 degrees, 28 minutes, 35 seconds) to decimal notation. Then convert 24.476° to sexagesimal notation.

Operation	Display
24 [D°M′S] **28** [D°M′S] **35** [2ndF] [↔DEG] Convert to decimal notation	
[CHANGE]	
[CHANGE]	
[2ndF] [↔DEG]	

Repeat last key operation to return to the previous display.

APPLICATIONS:
Used in calculations of angles and angular velocity in physics, and latitude and longitude in geography.

Fractional Calculations [a/b] [ab/c]

[a/b] Inputs proper or improper fractions which consist of a numerator and denominator.

[ab/c] Inputs a mixed fraction.

<Example> Add $3\frac{1}{2}$ and $\frac{5}{7}$, and convert to decimal notation.

Operation	Display
3 [2ndF] [ab/c] 1 [▶] 2 [▶] [+] 5 [a/b] 7 [=]	DEG W-VIEW $3\frac{1}{2}+\frac{5}{7}=$ N1 $4\frac{3}{14}$
[CHANGE] Convert to an improper fraction	DEG W-VIEW $3\frac{1}{2}+\frac{5}{7}=$ N1 $\frac{59}{14}$
[CHANGE] Convert to decimal notation	DEG W-VIEW $3\frac{1}{2}+\frac{5}{7}=$ N1 4.214285714
[CHANGE]	DEG W-VIEW $3\frac{1}{2}+\frac{5}{7}=$ N1 $4\frac{3}{14}$

APPLICATIONS:
There is a wide variety of applications for this function because fractions are such a basic part of mathematics. This function is useful for calculations involving electrical circuit resistance.

Memory Calculations STO RCL M+ M– A ~ F X Y M

STO □t□res dis□la□ed □alues in □e□□ries □□□□ □□ □□ □.

RCL □ecalls □alues st□red in □□□□ □□ □□ □.

M+ □dds the dis□la□ed □alue t□ the □alue in the inde□endent □e□□r□ □.

M– □u□tracts the dis□la□ed □alue □r□□ the □alue in the inde□endent □e□□r□ □.

A ~ F X Y □e□□□rar□ □e□□ries

M □nde□endent □e□□r□

<Example 1>

Operation	Display
0 STO M □□nter □ □□r □□	DEG W-VIEW 0⇒M N1 0.
25 × 27 M+	DEG W-VIEW M 25×27M+ N1 675.
7 × 3 M+	DEG W-VIEW M 7×3M+ N1 21.
RCL M	DEG W-VIEW M M= N1 696.

<Example 2>

Calculates $/¥ at the designated exchange rate.
$1 = ¥110
¥26,510 = $?
$2,750 = ¥?

Operation	Display
110 STO Y	DEG W-VIEW 110⇒Y N1 110.
26510 ÷ RCL Y =	DEG W-VIEW 26510÷Y= N1 241.
2750 × RCL Y =	DEG W-VIEW 2750×Y= N1 302'500.

Last Answer Memory [ANS]

ANS Automatically recalls the last answer calculated by pressing [=]

<Example> Solve for *x* first and then solve for *y* using *x*.

$$x = \sqrt{2} + 3 \quad \text{and} \quad y = 4 \div x$$

(Function for EL-W506X/EL-W516X/EL-W506)

Operation	Display
[2ndF] [√] 2 [▶] [+] 3 [=]	DEG W-VIEW √2+3= N1 3+√2
4 [÷] [ALPHA] [ANS] [=]	DEG W-VIEW 4÷ANS= N1 $\frac{12-4\sqrt{2}}{7}$
[CHANGE]	DEG W-VIEW 4÷ANS= N1 0.906163678

(Function for EL-W531X/EL-W535X/EL-W531XH/EL-W531XG/EL-W531)

Use [√] instead of [2ndF] [√] .

User-Defined Functions D1 ~ D4

D1 ~ D4 Recall a function that was defined by the user.

<Example>

Operation	Display
STO D1	DEG W-VIEW STORING D1 N1 SELECT FUNCTION
2ndF hyp sin^{-1}	DEG W-VIEW NORMAL MODE N1 0.
D1 26 =	DEG W-VIEW $sinh^{-1}26=$ N1 3.951613336

APPLICATIONS:
Functions that you have previously defined, including those using common 2nd Function buttons, can be stored in D1~ D4 for later use, thus saving time on keystrokes.

Absolute Value abs

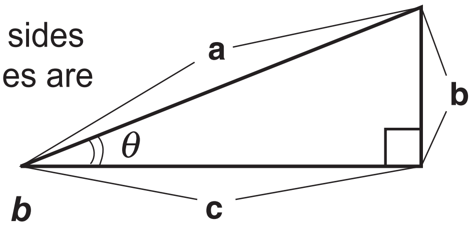
abs Returns an absolute value.

<Example>

Operation	Display
2ndF abs 3 × −4((−) 4) =	DEG W-VIEW |3×−4|= N1 12.

Trigonometric Functions sin cos tan

Trigonometric functions determine the ratio of three sides of a right triangle. The combinations of the three sides are sin, cos, and tan. Their relations are:



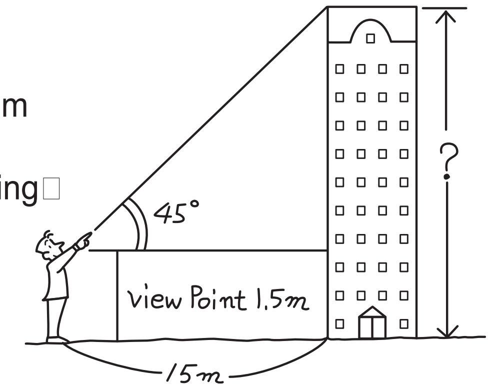
sin □alculates the sine of an angle. $\sin\theta = \frac{b}{a}$

cos □alculates the cosine of an angle. $\cos\theta = \frac{c}{a}$

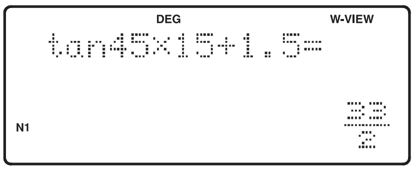
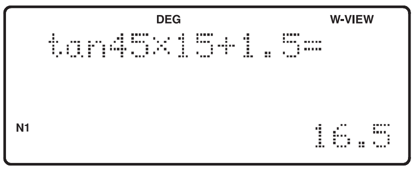
tan □alculates the tangent of an angle. $\tan\theta = \frac{b}{c}$

<Example 1>

The angle from a □oint1□ meters from a building to the highest floor of the building is □□□. □o□ tall is the building□



[DEG mode]

Operation	Display
tan 45 × 15 + 1 • 5 = (View point)	
CHANGE	
CHANGE	

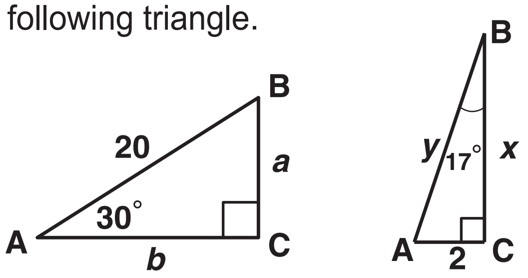
□□□□□□□□□O□□□

Trigonometric functions are useful in mathematics and □arious engineering calculations. The□ are often used in astronomical obser□ations, ci□il engi□neering and in calculations in□ol□ing electrical circuits, as □ell as in calcula□tions for □h□sics such as □arabolic motion and □a□e motion.

Trigonometric Functions [sin] [cos] [tan]

<Example 2>

Find the length of the side of the following triangle.



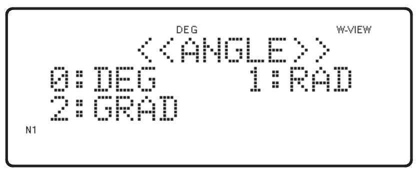
a = 20 sin 30
b = 20 cos 30

$$x = \frac{2}{\tan 17}$$

$$y = \frac{2}{\sin 17}$$

(Function for EL-W506X/EL-W516X/EL-W506)

[DEG mode]

Operation	Display
[2ndF] [SET UP] 0 (DRG) 0 (DEG) <Angle setting "∘" (DEG)>	

Trigonometric Functions [sin] [cos] [tan]

[ON/C]

20 [sin] 30 [=]

DEG W-VIEW
20sin30=
N1 10.

20 [cos] 30 [=]

DEG W-VIEW
20cos30=
N1 $10\sqrt{3}$

[a/b] 2 [▶] [tan] 17 [=]

DEG W-VIEW
$\frac{2}{\tan 17}=$
N1 6.541705237

[a/b] 2 [▶] [sin] 17 [=]

DEG W-VIEW
$\frac{2}{\sin 17}=$
N1 6.84060724

(Function for EL-W531X/EL-W535X/EL-W531XH/EL-W531XG/EL-W531)

Use [SET UP] instead of [2nd F] [SET UP] .

Trigonometric Functions [√] [sin] [π] [BS]

<Example 3>

The instantaneous value *V* of the AC voltage is expressed by the equation below.

$$V = \sqrt{2}V_e\sin(2\pi ft)\ [V]$$

Root mean square value V_e = 100 [V]

Frequency f = 60 [Hz]

Find the instantaneous value of the AC voltage at time t = 2.000, 2.002, 2.004, 2.008, 2.012, 2.016

(Function for EL-W506X/EL-W516X/EL-W506)

Operation	Display
[2ndF] [SET UP] 0 (DRG) 1 (RAD) <Angle setting "rad" (RAD)>	DEG W-VIEW <<ANGLE>> 0:DEG 1:RAD 2:GRAD N1
[ON/C] [2ndF] [√] 2 [▶] [×] 100 [sin] [(] 2 [×] [2ndF] [π] [×] 60 [×] 2.000 [)] [=]	RAD W-VIEW (2×π×60×2.000)_ N1
	RAD W-VIEW √2×100sin(2×π×60 N1 0.
[◀] [◀] [BS] 2 [=]	RAD W-VIEW (2×π×60×2.002 N1
	RAD W-VIEW √2×100sin(2×π×60 N1 96.80958013

Trigonometric Functions [√] [sin] [π] [BS]

[◄] [◄] [BS] 4
[=]

```
(2×π×60×2.004
```

```
√2 ×100sin(2×π×60
            141.1422935
```

[◄] [◄] [BS] 8
[=]

```
(2×π×60×2.008
```

```
√2 ×100sin(2×π×60
            17.72479587
```

[◄] [◄] [BS] [BS] 12
[=]

```
(2×π×60×2.012
```

```
√2 ×100sin(2×π×60
           -138.9163952
```

[◄] [◄] [BS] [BS] 16
[=]

```
(2×π×60×2.016
```

```
√2 ×100sin(2×π×60
            -35.17006113
```

(Function for EL-W531X/EL-W535X/EL-W531XH/EL-W531XG/EL-W531)

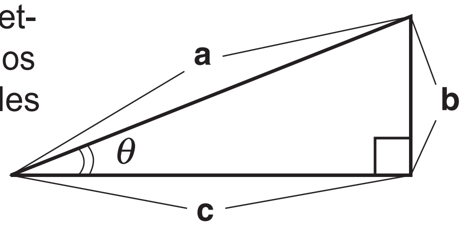
Use [SET UP] instead of [2ndF] [SET UP].

Use [√] instead of [2ndF] [√].

Use [π] instead of [2ndF] [π].

Arc Trigonometric Functions $\sin^{-1}$ $\cos^{-1}$ $\tan^{-1}$

Arc trigonometric functions, the inverse of trigonometric functions, are used to determine an angle from ratios of a right triangle. The combinations of the three sides are $\sin^{-1}$, $\cos^{-1}$, and $\tan^{-1}$. Their relations are;



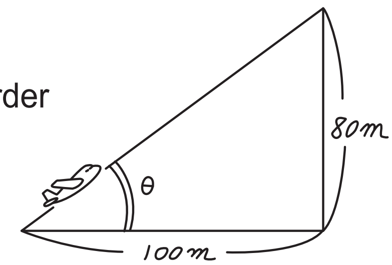
$\sin^{-1}$ (arc sine) Determines an angle based on the ratio *b*/*a* of two sides of a right triangle. $\theta = \sin^{-1}\frac{b}{a}$

$\cos^{-1}$ (arc cosine) Determines an angle based on the ratio *c*/*a* for two sides of a right triangle. $\theta = \cos^{-1}\frac{c}{a}$

$\tan^{-1}$ (arc tangent) Determines an angle based on the ratio *b*/*c* for two sides of a right triangle. $\theta = \tan^{-1}\frac{b}{c}$

<Example 1>

At what angle should an air□lane climb in order to climb □□ meters in1□□ meters□



[DEG mode]

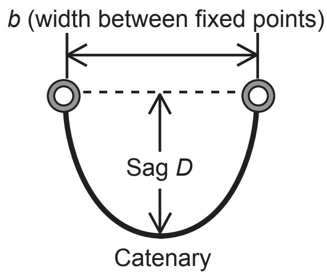
Operation	Display
2ndF $\tan^{-1}$ (80 ÷ 100) =	DEG W-VIEW tan⁻¹(80÷100)= N1 38.65980825

Hyperbolic [hyp] [cos] [sin]

<Example 1>

The curve that forms when a rope hangs from two fixed points is called a "catenary", and the sag *D* of the rope can be expressed using a hyperbolic function.

$$D = a\cosh\frac{b}{2a} - a$$

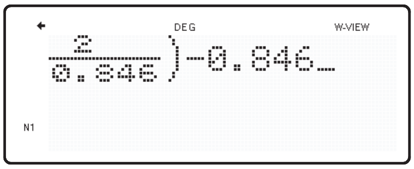
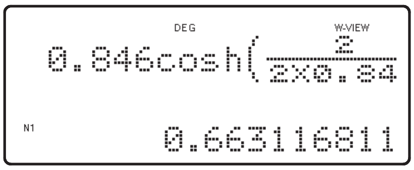
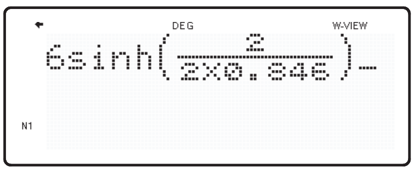
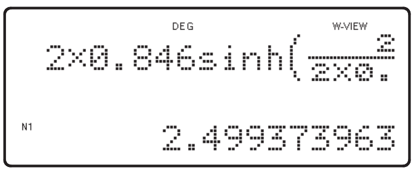


The length *L* of rope that creates this sag is expressed by the following equation.

$$L = 2a\sinh\frac{b}{2a}$$

When a = 0.846 and b = 2, find the rope sag *D* and the rope length *L*.

* The value *a* is called the catenary factor, and determines the shape of the curve.

Operation	Display
[ON/C] 0.846 [hyp] [cos] [(] [a/b] 2 [▶]	
2 [×] 0.846 [▶] [)] [−] 0.846 [=]	
[ON/C] 2 [×] 0.846 [hyp] [sin] [(] [a/b]	
2 [▶] 2 [×] 0.846 [▶] [)] [=]	

Hyperbolic

[A] [hyp] [tan] [B] [X] [MATH]

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>

A drop of rain falls against an air resistance proportional to the square of the fall velocity. The velocity *v* at time *t* seconds after the start of the fall is given by the following equation:

$$v = A\tanh Bt \text{ [m/s]}$$

A = 6.82
B = 1.44
(*A* and *B* are constants determined by a raindrop diameter of 1 mm and the physical properties of air.)

Find the fall velocity at time *t* = 0, 1, 2, 5, 10, 15.

*As the calculations are continued, *v* approaches 6.82. Therefore, the velocity of a raindrop is about 6.82 m/s (24.6 km/h) when it reaches the ground.

Note: The fall distance from time *t* = 0 to 15 [s] is given by the following equation. (Calculation of integral)

$$\int_0^{15} (6.82\tanh(1.44x))dx = 99.01718518$$

Answer

x	v
0	0
1	6.0950185
2	6.777153851
5	6.819992397
10	6.82
15	6.82

Additional note: Simulation calculation

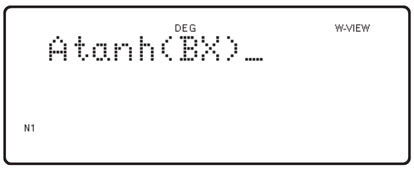
This function is convenient for repeated calculations using varying values of *X*.
1. Enter *A*tan*h*(*BX*) (use the characters *A*, *B*, and *X* to enter)

[DEG mode]

Operation

[ON/C] [ALPHA] [A] [hyp]
[tan] [(] [ALPHA] [B]
[ALPHA] [X] [)]

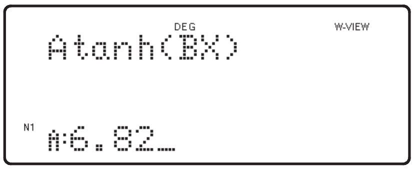
Display



2. Press the [MATH] key and select [ALGB]

MATH 1 (ALGB)

<Simulation calculation>



3. Enter the value of *A*

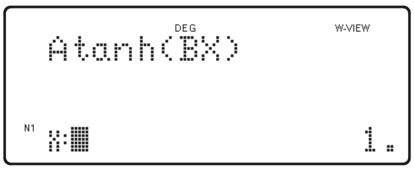
6.82 [=]

(If 6.82 appears, press only the [=] key)

4. Enter the value of *B*

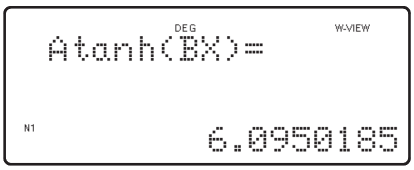
1.44 [=]

(If 1.44 appears, press only the [=] key)



5. Enter the value of *X*
For example,

1 [=]



6. The answer is obtained.
Repeat 2 to 6

Hyperbolic Functions hyp arc hyp

hyp The hyperbolic function is defined by using natural exponents in trigonometric functions.

arc hyp Arc hyperbolic functions are defined by using natural logarithms in trigonometric functions.

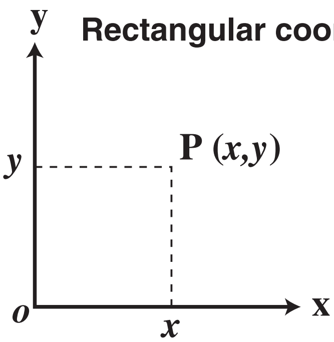
APPLICATIONS:
Hyperbolic and arc hyperbolic functions are very useful in electrical engineering and physics.

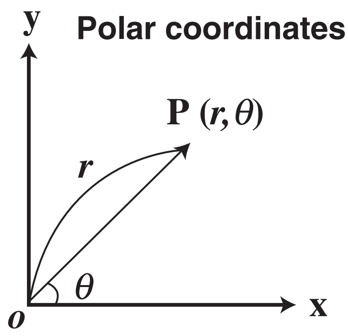
Coordinate Conversion →rθ →xy (x,y)

→rθ Converts rectangular coordinates to polar coordinates (x, $y \rightarrow r$, θ)

→xy Converts polar coordinates to rectangular coordinates (r, $\theta \rightarrow x$, y)

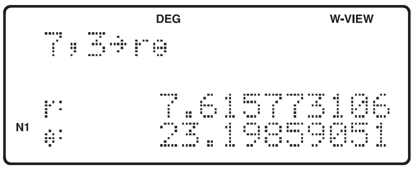
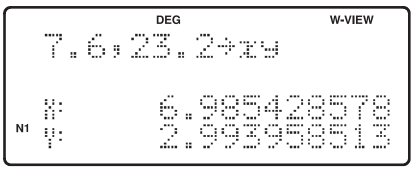
(x,y) Splits data used for dual-variable data input.





<Example> Determine the polar coordinates (r, θ) when the rectangular coordinates of Point P are (x = 7, y = 3).

[DEG mode]

Operation	Display
7 (x,y) 3 2ndF →rθ	
7.6 (x,y) 23.2 2ndF →xy	

□□□□□□□□□O□□□

Coordinate conversion is often used in mathematics and engineering, especially for impedance calculations in electronics and electrical engineering.

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

→BIN →PEN →OCT →DEC →HEX

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

→BIN Converts to the binary system. □□IN□ appears.

→PEN Converts to the pental system. □□EN□ appears.

→OCT Converts to the octal system. □OCT□ appears.

→HEX Converts to the hexadecimal system. □□EX□ appears.

→DEC Converts to the decimal system. □□IN□, □□EN□, □OCT□, and □□EX□ disappear from the display.

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

<Example 1> HEX(1AC) →BIN →PEN →OCT →DEC

Operation	Display
2ndF →HEX 1AC	1AC_ / HEX
2ndF →BIN	1AC→BIN / BIN 110101100
2ndF →PEN	ANS→PEN / PEN 3203
2ndF →OCT	ANS→OCT / OCT 654
2ndF →DEC	ANS→DEC / 428.

<Example 2> 1011 AND 101 = (BIN) →DEC

Operation	Display
ON/C 2ndF →BIN 1011 AND 101 =	1011AND101= / BIN 1
2ndF →DEC	ANS→DEC / 1.

Differentiation calculation [d/dx] [x]

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 1>

If the demand curve is expressed by

$$D = \frac{25920}{P} - 24$$

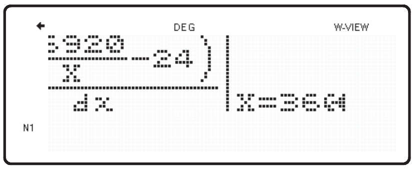
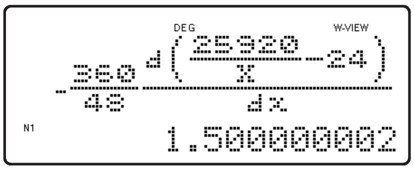
find the price elasticity of demand when *P*=360 (*D*=48).

*Price elasticity of demand:
A value that indicates how sensitive demand is to changes of price.

$$\text{Price elasticity of demand} = -\frac{\text{Rate of demand change}}{\text{Rate of price change}} = -\frac{\frac{dD}{D}}{\frac{dP}{P}} = -\frac{P}{D}\frac{dD}{dP}$$

Find the following value when *P*=360 and *D*=48.

$$-\frac{P}{D}\frac{d\left(\frac{25920}{x} - 24\right)}{dx}\Bigg|_{x=360}$$

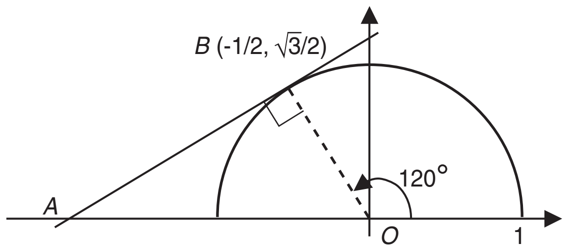
Operation	Display
[ON/C] [(−)] [a/b] 360	
[▶] 48 [▶] [2ndF]	
[d/dx] [a/b] 25920 [▶]	
[ALPHA] [x] [▶] [−]	
24 [▶] 360 [=]	

Differentiation calculation

d/dx √ x [x^2] [(−)]

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>

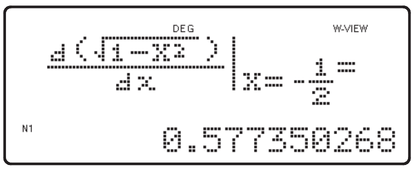


The semicircle above is given by the equation

$$y = \sqrt{1 - x^2}$$

Find the slope of the tangent *AB* at point *B* (-1/2, √3/2) on the semicircle.

$$\left. \frac{d(\sqrt{1 - x^2})}{dx} \right|_{x = -\frac{1}{2}}$$

<u>Operation</u>	<u>Display</u>
[ON/C] [2ndF] [d/dx] [2ndF]	
[√] 1 [−] [ALPHA]	
[x] [x^2] [▶] [▶]	
[(−)] (NEG) [a/b] 1 [▶]	
2 [=]	

Integration calculation [∫dx] [x]

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 1>

Let the demand curve of the overall market be $D = 3000 - 10P$, the supply curve be $S = 20P$, the equilibrium price be 100, and the equilibrium output be 2000.

(1) Find the consumer surplus of the overall market.

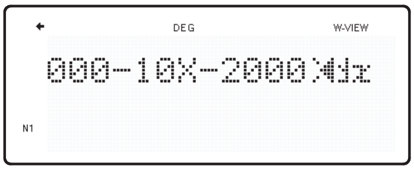
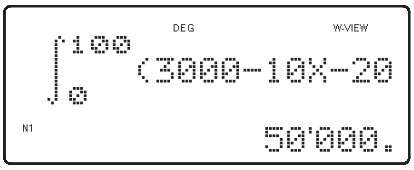
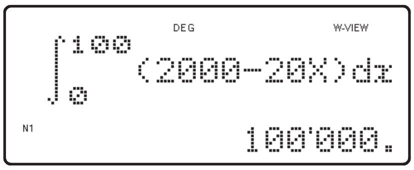
$$\int_0^{100} (3000 - 10x - 2000)\, dx$$

(2) Find the producer surplus of the overall market.

$$\int_0^{100} (2000 - 20x)\, dx$$

(3) Find the total surplus of the overall market.

$$\int_0^{100} (3000 - 10x - 20x)\, dx$$

Operation	Display
(1)	
[ON/C] [∫dx] 0 [▶]	
100 [▶] [(] 3000	
[−] 10 [ALPHA] [x]	
[−] 2000 [)] [=]	
(2)	
[ON/C] [∫dx] 0 [▶]	
100 [▶] [(] 2000	
[−] 20 [ALPHA] [x]	
[)] [=]	

Integration calculation [∫dx] [x]

(3)

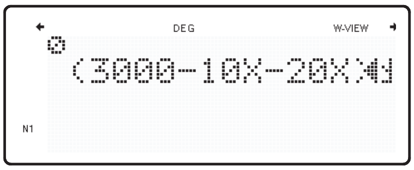
[ON/C] [∫dx] 0 [▶]

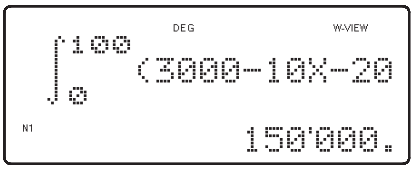
100 [▶] [(] 3000

[−] 10 [ALPHA] [x]

[−] 20 [ALPHA] [x]

[)] [=]

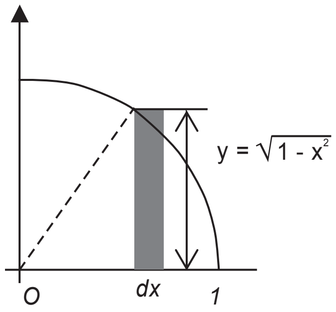




Integration calculation [∫dx] [2ndF][√] [ALPHA][x] [x²]

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>



The fan shaped curve at left is given by the equation

$$y = \sqrt{1 - x^2}$$

Find the area of the fan shape with radius 1 and central angle 90°.

$$\int_0^1 \sqrt{1 - x^2}\, dx$$

Operation	Display
[ON/C] [∫dx] 0 [▶]	
1 [▶] [2ndF] [√]	
1 [−] [ALPHA] [x]	
[x²] [=]	DEG W-VIEW $\int_0^1 \sqrt{1-X^2}\,dx=$ N1 0.785357562

Polynomial equation

MODE Exp (−) STO B C log

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 1>

Let the hydrochloric acid concentration be *c* (= 1.0 x 10^{-8} mol / ℓ), and the hydrogen ion concentration be *x*.

(1) Solve the following quadratic equation to find the hydrogen ion concentration *x*:

$$x^2 - cx - K_w = 0$$

where

K_w = 1.0 x 10^{-14} [mol / ℓ] (ionic product of water)

(2) Use the result of (1) to find the pH (= - log *x*) of hydrochloric acid.

pH = - log *x* (*x*>0)

	Operation	**Display**
(1)		
Save constants		
	MODE 0 (NORMAL) ON/C	
	1.0 Exp (−) NEG 14	
	STO B	
	1.0 Exp (−) NEG 8	DEG W-VIEW 1.0E-8⇒C N1 0.00000001
	STO C	

Polynomial equation

MODE Exp (−) STO B C log

Set the mode to Equation

MODE **6 (EQUATION) 2 (QUAD)**

<Quadratic equation>

```
DEG                    W-VIEW
   <<EQUATION>>
 0:2-VLE    1:3-VLE
 2:QUAD     3:CUBIC
N1
```

Solve the equation (enter coefficients a, b, c)

1 ENTER

(−) NEG ALPHA C ENTER

(−) NEG ALPHA B ENTER

```
DEG
 X=
 1:      0.000000105
 2:     -0.000000095
N1
```

(2)

Set the mode to Normal

MODE **0 (NORMAL)**

```
DEG                    W-VIEW
 NORMAL MODE

N1                         0.
```

ON/C (−) log

0.000000105 =

```
DEG                    W-VIEW
 -log0.000000105=

N1              6.978810701
```

Polynomial equation

MODE Exp (−) STO A B C log

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>

Let the acetic acid concentration be c (= 0.1 mol / ℓ), and the hydrogen ion concentration be x.

(1) Solve the following quadratic equation to find the hydrogen ion concentration x:

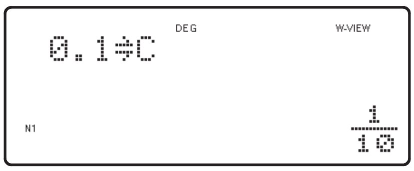
$$\boldsymbol{x^3 + K_a x^2 - (cK_a + K_w)x - K_a K_w = 0}$$

where

K_a = 2.75 x 10^{-5} [mol / ℓ] (ionization equilibrium constant of acetic acid)
K_w = 1.0 x 10^{-14} [mol / ℓ] (ionic product of water)

(2) Use the result of (1) to find the pH (= - log x) of acetic acid.

pH = - log x (x>0)

Operation	Display
(1)	
Save constants	
MODE 0 (NORMAL) ON/C	
2.75 Exp (−) [NEG] 5	
STO A	
1.0 Exp (−) [NEG] 14	
STO B	
0.1 STO C	

Polynomial equation

MODE Exp (−) STO A B C log

Set the mode to Equation

MODE 6 (EQUATION)

3 (CUBIC)

<Cubic equation>

```
DEG                W-VIEW
   <<EQUATION>>
0:2-VLE   1:3-VLE
2:QUAD    3:CUBIC
N1
```

Solve the equation (enter coefficients a, b, c, d)

1 ENTER

ALPHA A ENTER

(−) NEG (ALPHA C

ALPHA A + ALPHA

B) ENTER (−) NEG

ALPHA A ALPHA B

=

```
DEG
X=
1:     -0.001672119
2:      0.001644619
3:     -9.99413E-14
N1
```

(2)

Set the mode to Normal

MODE 0 (NORMAL)

```
DEG                W-VIEW
NORMAL MODE
N1
                      0.
```

ON/C (−) log

0.001644619 =

```
DEG                W-VIEW
-log0.001644619=
N1
           2.783934697
```

Simultaneous Calculation MODE

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 1>

To produce one unit of product *X*, 3 kg of material *A* and 1 kg of material *B* are required.
To product one unit of product *Y*, 1 kg of material *A* and 2 kg of material *B* are required.
There are 9 kg of *A* and 8 kg of *B* in stock.
If the selling price of product *X* is 30,000 yen/unit and the selling price of product *Y* is 20,000 yen/unit, how many units of product *X* and how many units of product *Y* should be produced in order to maximize sales *K*?
(Do not include the cost of materials and production or other expenses)

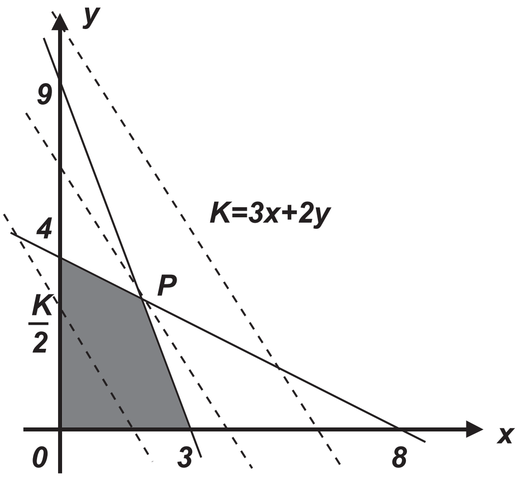
If the quantities produced of each product are x and y, the sales *K* can be expressed as

$$K = 3x + 2y$$

The following relations hold for the quantities in stock:

$$3x + y \leq 9$$
$$x + 2y \leq 8$$
$$x \geq 0,\ y \geq 0$$

Based on these conditions, find the values of x and y that maximize sales *K*.



The conditions can be graphed as shown above.
The sales *K* is a maximum where the line $K = 3x + 2y$ passes through the intersection point *P* of lines $3x + y = 9$ and $x + 2y = 8$.

The intersection point P can be obtained from the following simultaneous equations:

$$3x + y = 9$$
$$x + 2y = 8$$

Solving these gives

$x = 2$, $y = 3$

and thus the maximum value of the sales *K* is

$K = 3 \times 2 + 2 \times 3 = 12$ (x 10,000) yen (when $x = 2$ units and $y = 3$ units)

Simultaneous Calculation [MODE]

(1) Solve the following simultaneous equations.

$3x + y = 9$
$x + 2y = 8$

(2) Use the result of (1) to find the following value.

$K = 3x + y$

Operation	Display
(1)	
Set the mode to Equation [MODE] **6 (EQUATION)** <Equation mode>	DEG W-VIEW <<EQUATION>> 0:2-VLE 1:3-VLE 2:QUAD 3:CUBIC N1
0 (2-VLE) <Simultaneous linear equations in two unknowns>	DEG a1 = 0. b1 N1 = 0.
Enter the coefficients a1 = 3 , b1 = 1 , c1 = 9 a2 = 1 , b2 = 2 , c2 = 8	
3 [ENTER] 1 [ENTER] 9 [ENTER] 1 [ENTER] 2 [ENTER] 8 [ENTER]	DEG X: 2. Y: 3. D: 5. N1
(2)	
Set the mode to Normal [MODE] **0 (NORMAL)**	DEG W-VIEW NORMAL MODE N1 0.
3 [×] 2 [+] 2 [×] 3 [=]	DEG W-VIEW 3×2+2×3= N1 12.

Simultaneous Calculation MODE

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>

When ethanol C_2H_5OH is completely combusted, carbon dioxide CO_2 and water H_2O are created.
The chemical reaction formula of this reaction is expressed as follows:

$$x\, C_2H_5OH + 3O_2 \rightarrow y\, CO_2 + z\, H_2O$$

Find the values of x, y, and z to complete the chemical reaction formula.

The numbers of C, H, and O before and after the reaction are equal, hence

Number of C: $2x = y$
Number of H: $5x + 1 = y$
Number of O: $x + 3 \times 2 = z$

As such, the following simultaneous equations are obtained:

$$2x - y + \quad = 0$$
$$6x \quad - 2z = 0$$
$$x - 2y - z = -6$$

Solving these gives

$x = 1$, $y = 2$, $z = 3$

and the chemical reaction formula is

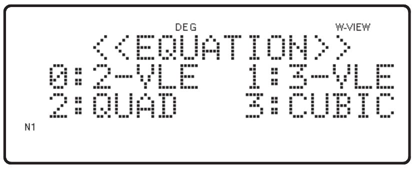
$$C_2H_5OH + 3O_2 \rightarrow 2CO_2 + 3H_2O$$

Operation	Display

Set the mode to Equation

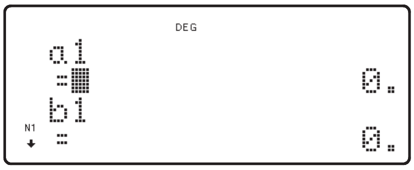
MODE **6 (EQUATION)**

<Equation mode>



1 (3-VLE)

<Simultaneous linear equations in three unknowns>



Enter the coefficients

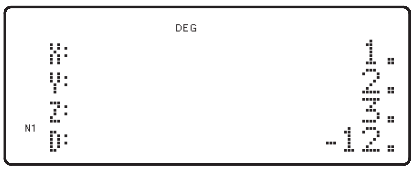
a1 = 2 , b1 = -1 , c1 = 0 , d1 = 0
a2 = 6 , b2 = 0 , c2 = -2 , d2 = 0
a3 = 1 , b3 = -2 , c3 = -1 , d3 = -6

2 ENTER (−) **1** ENTER **0** ENTER

0 ENTER **6** ENTER **0** ENTER

(−) **2** ENTER **0** ENTER **1** ENTER

(−) **2** ENTER (−) **1** ENTER (−) **6** ENTER



Complex Calculation

MODE, →xy, π, Exp, (−), i, SET UP, →rθ

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 1>

An AC sine wave voltage of 100 V, 50 Hz is applied to a circuit consisting of a resistor (R = 250Ω) and capacitor (C = 20 x 10^{-6}F) connected in parallel. Find the impedance of this circuit.

Circuit impedance = Value of polar coordinate r

Let R = 250, C = 20 x 10^{-6}, and f = 50.
If the complex number Z = $1 \div ((1 \div R) + 2\pi fCi)$,
find the value of the complex number Z and the values of r.

Operation	Display
[MODE] 3 (CPLX) Complex mode	DEG COMPLEX MODE xy N1 0.
[2ndF] [→xy] (Rectangular coordinates)	
1 [÷] [(] [(] 1 [÷] 250 [)] [+] 2 [2ndF] [π] [×] 50 [×] 20 [Exp] [(−)] 6 [i] [)] [=]	DEG 1÷((1÷250)+2π×50 xy ×20E -6i)= 72.10010979 N1 -113.2545876i
[2ndF] [SET UP] 0 (DRG)	DEG <<ANGLE>> xy 0:DEG 1:RAD 2:GRAD N1
1 (RAD) (Angle units: RAD) [2ndF] [→rθ] (Polar coordinates)	RAD 1÷((1÷250)+2π×50 rθ ×20E -6i)= 134.257318 N1 ∠-1.003884822

Complex Calculation

[→xy] [π] [i] [Exp] [(−)] [SET UP] [→rθ]

(Function for EL-W506X/EL-W516X/EL-W506)

<Example 2>

An AC sine wave voltage of 100V, 60Hz is applied to a circuit consisting of a resistor (R = 120Ω), coil (L = 4 H), and capacitor (C = 3 x 10^{-6}F) connected in series.

(1) Find the impedance of the circuit.
(2) Find the phase difference φ between the current and the voltage.

Circuit impedance = Value of polar coordinate r
Phase difference = Polar coordinate θ

Let R = 120, L = 4, C = 3 x 10^{-6}, and f = 60. If the complex number $Z = R + 2\pi fLi + 1 \div (2\pi fCi)$, find the value of the complex number Z and the values of r and θ.

Operation	Display
[ON/C] [2ndF] [→xy] (rectangular coordinats)	
120 [+] 2 [2ndF] [π] [×] 60 [×] 4 [×] [i] [+] 1 [÷] [(] 2 [2ndF] [π] [×] 60 [×] 3 [Exp] [(−)] 6 [i] [)] [=]	RAD xy 120+2π×60×4×i+1÷(2π×60×3E-6i)= N1 120. +623.7703454i
[2ndF] [SET UP] 0 (DRG) 0 (DEG) (Angle units: DEG) [2ndF] [→rθ] (Polar coordinates)	DEG rθ 120+2π×60×4×i+1÷(2π×60×3E-6i)= N1 635.2081894 ∠79.110561

Statistics Functions

The statistics function is excellent for analyzing qualities of an event. Though primarily used for engineering and mathematics, the function is also applied to nearly all other fields including economics and medicine.

DATA INPUT AND CORRECTION

DATA: Enters data for statistical calculations.

CD: Clears data input.

(x,y): Splits data used for dual-variable data input. (Used for dual-variable statistical calculations.)

<Example 1> Here is a table of examination results. Input this data for analysis.

Data table 1

No.	1	2	3	4	5	6	7	8
Score	30	40	50	60	70	80	90	100
No. of pupils	2	4	5	7	12	10	8	2

Operation	Display
MODE 1 0 Select single-variable statistics mode	DEG Stat 0 [SD] N1 0.
30 (x,y) 2 DATA	DEG 30,2DATA N1 DATA SET= 1.
⋮	
100 (x,y) 2 DATA	DEG 100,2DATA N1 DATA SET= 8.

"ANS" KEYS FOR 1-VARIABLE STATISTICS

[$\bar{x}$] Calculates the average value of the data (sample data *x*).

[sx] Calculates the standard deviation for the data (sample data *x*).

[σx] Calculates the standard deviation of a data population (sample data *x*).

[n] Displays the number of input data (sample data *x*).

[Σx] Calculates the sum of the data (sample data *x*).

[Σx^2] Calculates the sum of the data (sample data *x*) raised to the second power.

NOTE:
1. Sample data refers to data selected randomly from the population.
2. Standard deviation of samples is determined by the sample data shift from an average value.
3. Standard deviation for the population is standard deviation when the sample data is deemed a population (full data).

Let's check the results based on the previous data.

[RCL] [$\bar{x}$] 69 (average value)

[RCL] [sx] 17.75686128 (standard deviation)

[RCL] [σx] 17.57839583 (standard deviation of the population)

[RCL] [n] 50 (total count of data)

[RCL] [Σx] 3450 (total)

<Example 2>

No	Weight [g]
1	97.27
2	96.83
3	96.65
4	96.90
5	96.77

When the weight of a calculator was measured,
the results at left were obtained.
Find the average and standard deviation of the weight.

Operation	**Display**
MODE 1 (STAT) 0 (SD) Select Statistics mode	DEG <<STAT-1>> 0:SD 1:LINE 2:QUAD 3:E_EXP 4:LOG 5:POWER
2ndF CA	
97.27 DATA 96.83 DATA ••• 96.77 DATA	DEG 96.77DATA DATA SET= 5.
Average ALPHA $\bar{x}$ =	DEG $\bar{x}$= 96.884
Standard deviation ALPHA σx =	DEG σx= 0.209723627

<Example 3>

Spring extension *x* [m]	Force *F* [N]
0.028	0.2
0.073	0.39
0.118	0.6
0.16	0.77
0.207	1

When a weight was hung on a spring, the following relation was obtained for the extension of the spring and the force applied to the spring. Use linear regression to find the coefficients *a* and *b* of the relational expression $y = a + bx$, and the correlation coefficient *r*.

Operation	**Display**
MODE 1 (STAT) 1 (LINE) Select Statistics mode	DEG <<STAT-1>> 0:SD 1:LINE 2:QUAD 3:E_EXP 4:LOG 5:POWER
2ndF CA	
0.028 (x,y) 0.20 DATA 0.073 (x,y) 0.39 DATA ... 0.207 (x,y) 1.00 DATA	DEG 0.207,1.00DATA DATA SET= 5.
ALPHA a =	DEG a= 0.070355029
ALPHA b =	DEG b= 4.450895652
ALPHA r =	DEG r= 0.999620559

<Example 4>

The hot water inside an electric pot is maintained at 92°C.
When a thermometer is placed in this hot water, the values indicated by the thermometer at times x and the differences y between these values and the temperature of the hot water are shown below. Using Euler's exponential regression, find the formula that expresses the relation between each time x and the temperature difference y.

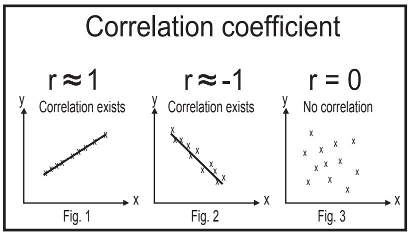
(Room temperature 25°C, hot water temperature 92°C)

Time x [S]	Thermometer temperature [°C]	Temperature difference y [°C] from liquid
0	25	67
4	55	37
8	71	21
12	79	13
16	85	7
20	88	4
24	90	2
28	90	2
32	91	1
36	91	1
40	91	1

e: Napier's constant
e=2.718281828···

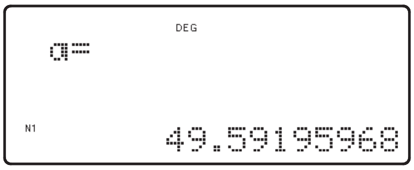
When x and y are in the following relationship, use Euler's exponential regression to find the coefficients a and b of the relational expression $y = ae^{bx}$, and the correlation coefficient r.

x	y
0	67
4	37
8	21
12	13
16	7
20	4
24	2
28	2
32	1
36	1
40	1

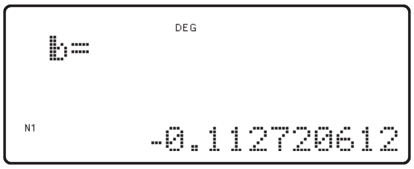


Operation	Display
MODE 1 (STAT) 3 (E_EXP) Select Statistics mode	DEG <<STAT-1>> 0:SD 1:LINE 2:QUAD 3:E_EXP 4:LOG 5:POWER
2nd F CA	
0 (x,y) 67 DATA	
4 (x,y) 37 DATA	
...	
40 (x,y) 1 DATA	DEG 40,1DATA DATA SET= 11.

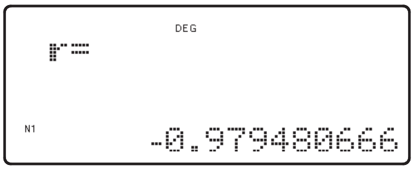
[ALPHA] [a] [=]



[ALPHA] [b] [=]



[ALPHA] [r] [=]



DATA CORRECTION

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

Correction after pressing [DATA]:

Use [▲] [▼] to display the data previously entered.
Press [▼] to display data items in ascending (oldest first) order. To reverse the display order to descending (latest first), press the [▲] key.
Each item is displayed with 'X:', 'Y:', or 'F:' (n is the sequential number of the data set).
Display the data item to modify, input the correct value, then press [DATA].
Using [(x,y)], you can correct the values of the data set all at once.

- When ▲ or ▼ appears, more data items can be browsed by pressing [▲] or [▼].
- To delete a data set, display an item of the data set to delete, then press [2ndF] [CD]. The data set will be deleted.
- To add a new data set, press [ON/C] and input the values, then press [DATA].

<Example 1>

Data table 2

X: 30, 40, 40, 50

⬇

X: 30, 45, 45, 45, 60

Operation	Display
[MODE] [1] [0] Select single-variable statistics mode	DEG Stat 0 [SD] N1 0.
30 [DATA]	DEG 30DATA N1 DATA SET= 1.
40 [(x,y)] 2 [DATA]	DEG 40,2DATA N1 DATA SET= 2.
50 [DATA]	DEG 50DATA N1 DATA SET= 3.

Operation	Display
▼ ▼ ▼	DEG DATA SET= 2 X: 40. F: 2. N1
45 (x,y) 3 DATA	DEG DATA SET= 2 X: 45. F: 3. N1
▼	DEG DATA SET=3 X: 50. F: 1. N1
▼ 60 DATA	DEG DATA SET= 3 X: 50. F: 60. N1

APPLICATIONS:
Single-variable statistical calculations are used in a broad range of fields, including engineering, business, and economics. They are most often applied to analysis in atmospheric observations and physics experiments, as well as for quality control in factories.

<Example 2> The table below summarizes the dates in April when cherry blossoms bloom, and the average temperature for March in that same area. Determine basic statistical quantities for data X and data Y based on the data table.

Data table 3

	Year	1998	1999	2000	2001	2002	2003	2004	2005
x	**Average temperature**	6.2	7.0	6.8	8.7	7.9	6.5	6.1	8.2
y	**Date blossoms bloom**	13	9	11	5	7	12	15	7

<u>**Operation**</u>	<u>**Display**</u>
[MODE] [1] [1]	DEG Stat 1 [LINE] N1 0.

Select dual-variable statistics mode and linear regression calculation in sub-mode.

6.2 [(x,y)] **13** [DATA]	DEG 6.2,13DATA N1 DATA SET= 1.
⋮	
6.1 [(x,y)] **15** [DATA]	DEG 6.1,15DATA N1 DATA SET= 7.
8.2 [(x,y)] **7** [DATA]	DEG 8.2,7DATA N1 DATA SET= 8.

"ANS" KEYS FOR 2-VARIABLE STATISTICS

In addition to the 1-variable statistic keys, the following keys have been added for calculating 2-variable statistics.

[Σxy]	Calculates the sum of the product for sample data *x* and sample data *y*.
[Σy]	Calculates the sum of the data (sample data *y*).
[Σy^2]	Calculates the sum of the data (sample data *y*) raised to the second power.
[$\bar{y}$]	Calculates the average value of the data (sample data *y*).
[sy]	Calculates the standard deviation for the data (sample data *y*).
[σy]	Calculates the standard deviation of a data population (sample data *y*).

NOTE:
The codes for basic statistical quantities of sample data *x* and their meanings are the same as those for single-variable statistical calculations.

Let' s check the results based on the previous data.

[RCL] [$\bar{x}$]	7.175	(Average for data *x*)
[RCL] [sx]	0.973579551	(Standard deviation for data *x*)
[RCL] [σx]	0.91070028	(Standard deviation of the population for data *x*)
[RCL] [$\bar{y}$]	9.875	(Average for data *y*)
[RCL] [sy]	3.440826313	(Standard deviation for data *y*)
[RCL] [σy]	3.218598297	(Standard deviation of the population for data *y*)
[RCL] [n]	8	(Total count of data)
[RCL] [Σx]	57.4	(Sum of data *x*)
[RCL] [Σx^2]	418.48	(Sum of data *x* raised to the second power)
[RCL] [Σxy]	544.1	(Sum of the product of data *x* and data *y*)
[RCL] [Σy]	79	(Sum of data *y*)
[RCL] [Σy^2]	863	(Sum of data *y* raised to the second power)

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