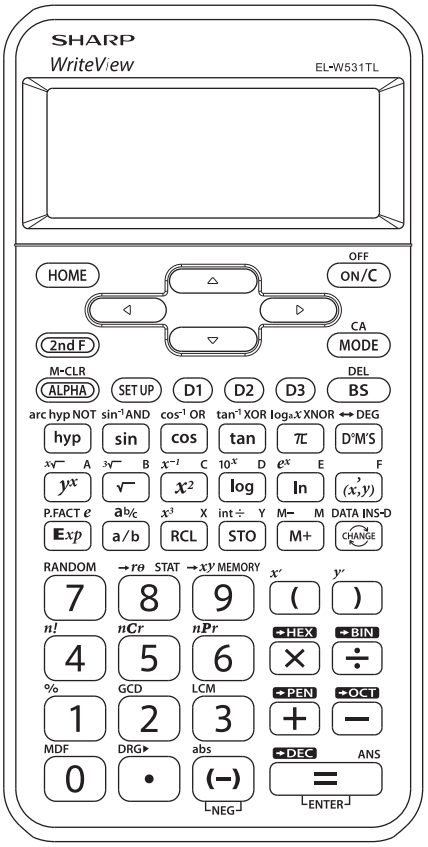
# SCIENTIFIC CALCULATOR OPERATION GUIDE

**< EL-W531TL/W531TH/W531TG/W506T >**




SHARP

# CONTENTS

## HOW TO OPERATE

### Read Before Using



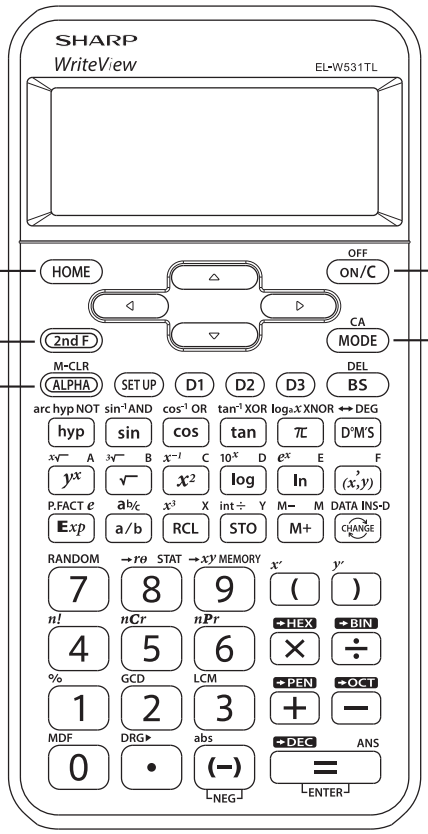
### Functions and Key Operations

# How to Operate

## ≈Read Before Using≈

This operation guide has been written mainly based on the EL-W531TL/W531TH/W531TG model. And some functions described here are featured on the EL-W506T model only. Note that key operations and symbols on the display may differ according to the model.

## 1. KEY LAYOUT (EL-W531TL)




### Mode key

This calculator can operate in four different modes as follows.

**[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 sub-mode, press the corresponding number key after MODE 1.

- 0 Single variable statistic calculation
- 1 Linear regression calculation
- 2 Quadratic regression calculation
- 3 Euler Exponential regression calculation
- 4 Logarithmic regression calculation
- 5 Power regression calculation
- 6 Inverse regression calculation
- 7 Exponential regression calculation

**[TABLE mode]** MODE 2 •Mode = 2; mode for showing the changes in values of a function in table format.

**[DRILL mode]** MODE 3 •Mode = 3; mode for performing drill calculations. To select the drill sub-mode, press the corresponding number key after MODE 3.

- 0 (MATH): Math drill
- 1 (TABLE): Multiplication table drill

### 2nd function, ALPHA keys

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

### ON/C, OFF key

ON/C <Power on>

2nd F OFF <Power off> Written in orange above the ON/C key

### HOME key

Pressing this key will return to NORMAL mode.

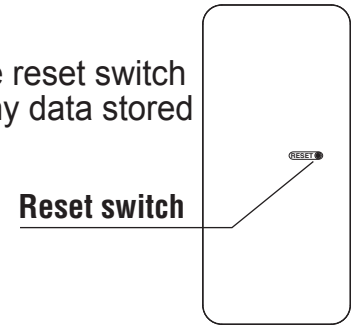
**NOTE:**

The EL-W506T model has another modes (Complex, Equation, Matrix, Vector and Distribution modes).

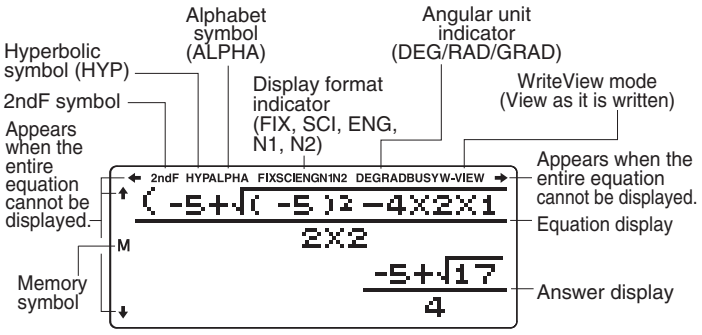
## 2. RESET SWITCH

If the calculator fails to operate normally, press the reset switch on the back to reinitialize 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




**NOTE:**
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 upper part of the display (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.

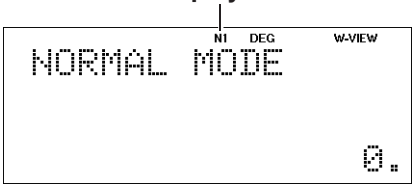
- **Floating decimal point format 1/2** (**N1**/**N2** is displayed)***1**
  Valid values beyond the maximum range are displayed in the form of [10-digit (mantissa) + 2-digit (exponent)]
- **Fixed decimal point format** (**FIX** is displayed)
  Displays the fractional part of the calculation result according 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.

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

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

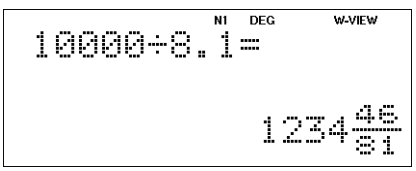
MODE 0

**Display format indicator**

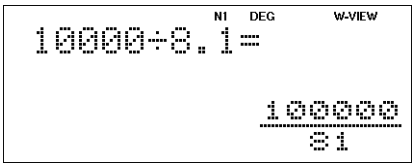



(NORM1 mode)

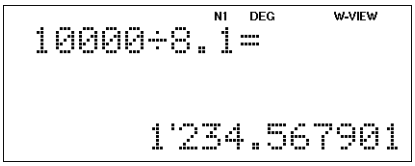
10000 ÷ 8.1 = (Mixed fractions)



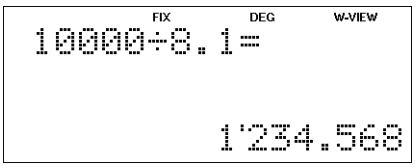
CHANGE (Improper fractions)




CHANGE (Decimal numbers)

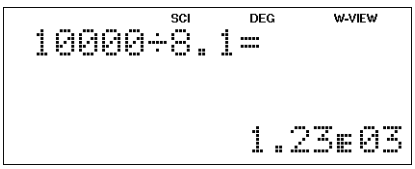



SET UP 1 0 3



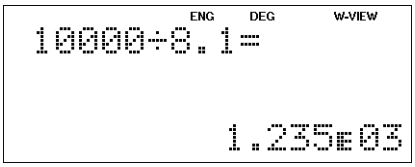

(FIX mode, TAB = 3)

SET UP 1 1 3



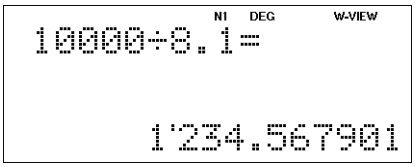

(SCI mode)

SET UP 1 2 3




(ENG mode)

SET UP 1 3




(NORM1 mode)

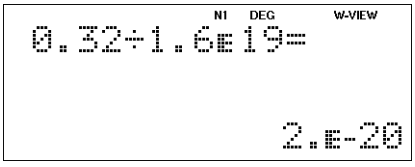
**NOTE:**
In EL-W506T, Use 2nd F SET UP instead of SET UP.

# 5. EXPONENT DISPLAY

The distance from the earth to the sun is approx. 150,000,000 ($1.5 \times 10^8$) 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 = $1.6 \times 10^{-19}$ coulombs).

0.32 ÷ 1.6 Exp 19 =



# 6. ANGULAR UNIT

Angular values are converted from DEG to RAD to GRAD with each push of the DRG► key (2nd function of [•]). 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)

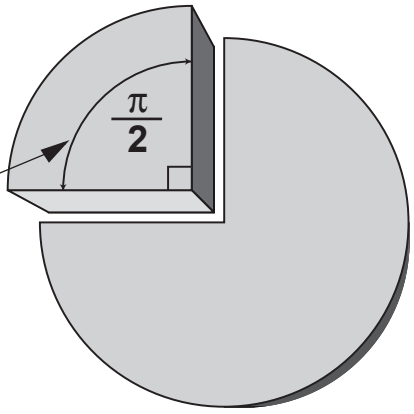
Radians are different from degrees and express angles based on the circumference of a circle. 180° is equivalent to π radians. Therefore, the angular measure of a circle is 2π radians.

## 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:

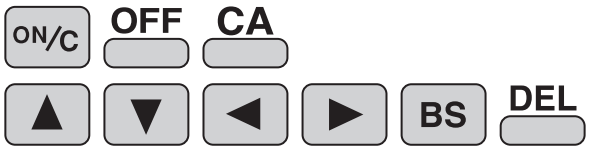
90° (DEG) =
π/2 (RAD) =
100 (GRAD) =




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

| Operation | Display |
|---|---|
| SET UP 0 0 (DEG) | NORMAL MODE<br>0. |
| 90 2nd F DRG► | 90►RAD<br>$\frac{1}{2}\pi$ |
| 2nd F DRG► | ANS►GRAD<br>100. |
| 2nd F DRG► | ANS►DEG<br>90. |

# ON/OFF, Entry Correction Keys



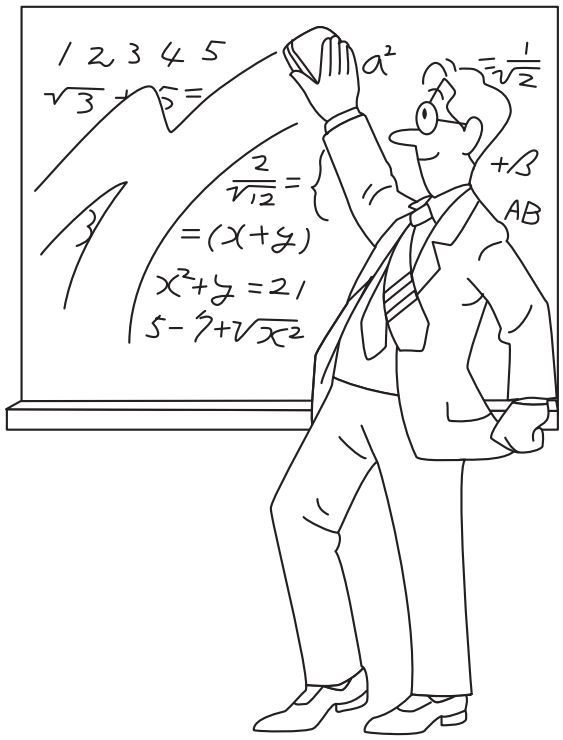

ON/C — Turns the calculator on or clears the data. It also clears the contents of the calculator display and voids any calculator command; however, statistics, as well as values stored in the memory, are not erased.

OFF — Turns the calculator off.

CA — Clears all internal values, including the last answer (ANS) and statistics. Values stored in memory 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] [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.

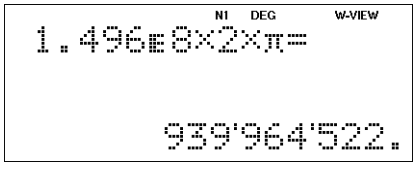
[π] Enters π (3.14159...).
The constant π, used frequently in function calculations, is the ratio of the circumference of a circle to its diameter

[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 $1.496 \times 10^8$ km.

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

| Operation | Display |
|---|---|
| 1.496 [Exp] 8 [×] 2 [×] [π] [=] |  |

# 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.

**NOTE:**
Using LINE mode is preferable, since the numbers are generated by fractions in W-VIEW mode. In W-VIEW mode, press CHANGE to convert it to decimal form.

## <Example>

SET UP 2 1 (LINE mode)

2nd F RANDOM 0 ENTER **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 2nd F 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 2nd F RANDOM 2 ENTER. To generate the next random coin number, press ENTER.

**[Random Integer]**
You can specify a range for the random integer with “R.Int(”.
R.Int(*minimum value*, *maximum value*)
For example, if you enter 2nd F RANDOM 3 1 (x,y) 99 ) ENTER, a random integer from 1 to 99 will be generated. 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...)

(In W-VIEW mode, press CHANGE to show the answer in decimal.)

× 9 = **5.0**

**Rounded calculation (MDF)**

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

(In W-VIEW mode, press CHANGE to show the answer in decimal.)

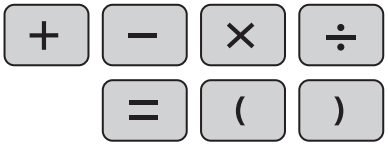
2ndF MDF (internally, 0.6)

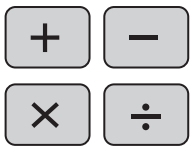
× 9 = **5.4**

(In W-VIEW mode, press CHANGE twice to show the answer in decimal.)

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

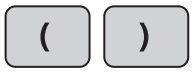
# Basic Arithmetic Keys, Parentheses




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.



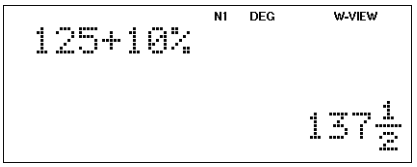

Used to specify calculations in which certain operations have precedence. You can make addition and subtraction operations have precedence over multiplication and division by enclosing them in parentheses.

# Percent %

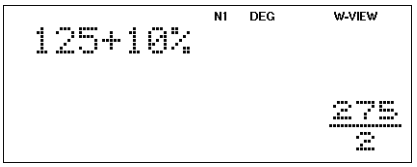
% For calculating percentages. Four methods of calculating percentages are presented as follows.

**1) $125 increased by 10%…137.5**

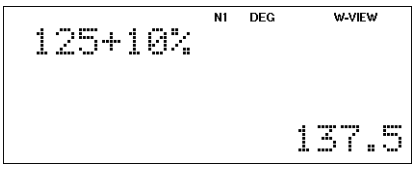
125 + 10 2ndF %




CHANGE

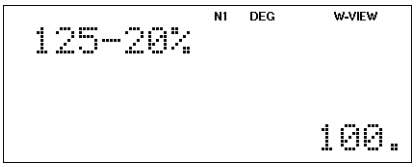



CHANGE




**2) $125 reduced by 20%…100**

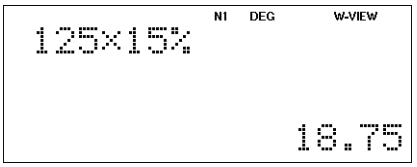
125 − 20 2ndF %




**3) 15% of $125…18.75**

125 × 15 2ndF %

CHANGE CHANGE




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

125 ÷ 5 2ndF %


**NOTE:**
In EL-W506T, when “(%)” is specified immediately after a value, the value is treated as a percentage. “(%)” is specified by MATH 6 .

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

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

[$x^{-1}$] Calculates the inverse of the value.

[$x^2$] Squares the value.

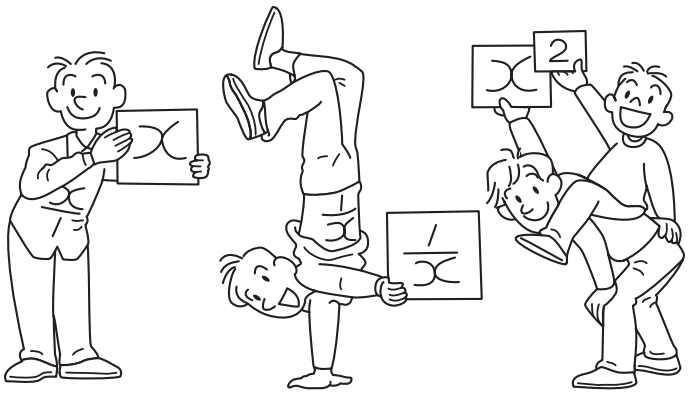
[$x^3$] Cubes the value.

[$yx$] Calculates the $x^{th}$ power of the value.

[$\sqrt{\ }$] Calculates the square root of the value.

[$3\sqrt{\ }$] Calculates the cube root of the value.

[$x\sqrt{\ }$] Calculates the $x^{th}$ root of the value.




**<Example>**

| Operation | Display |
|---|---|
| 2 [×] 2 [×] 2 [×] 2 [=] | N1 DEG W-VIEW<br>2×2×2×2=<br>16. |
| 2 [$yx$] 4 [=] | N1 DEG W-VIEW<br>$2^4$=<br>16. |
| 4 [2ndF] [$x\sqrt{\ }$] 16 [=] | N1 DEG W-VIEW<br>$\sqrt[4]{16}$=<br>2. |

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

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

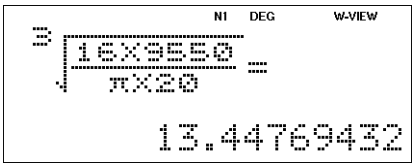
$$d = \sqrt[3]{\frac{16T}{\pi\tau}}$$

**Operation**

ON/C 2ndF $\sqrt[3]{\ }$ a/b 16 ×

9550 ▶ π × 20 =

**Display**



# 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*.

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

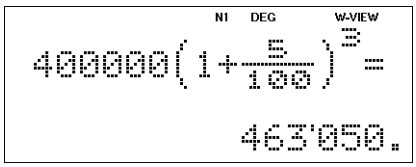
$$r = 100\left(\sqrt[5]{\frac{339422}{300000}} - 1\right)$$

**Operation** **Display**

(1)

ON/C 400000 ( 1 + a/b 5

▶ 100 ▶ ) $y^x$ 3 =

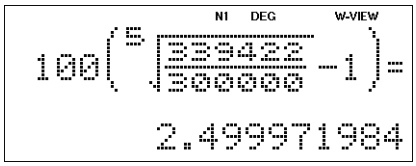



(2)

ON/C 100 ( 2ndF $\sqrt[x]{\ }$ 5 ▶

a/b 339422 ▶ 300000 ▶

▶ − 1 ) =



# Power and Radical root [yx] [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

$$440 \times (\sqrt[12]{2})^3$$

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

$$\frac{440 \times (\sqrt[12]{2})^3}{2}$$

(3) "A" one octave higher

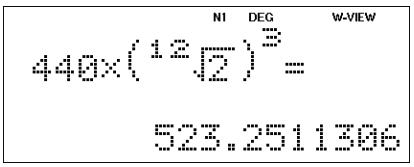
$$440 \times (\sqrt[12]{2})^{12}$$

**Operation** **Display**

(1)

[ON/C] 440 [×] [(] [2ndF] [x√‾] 12

[►] 2 [►] [)] [yx] 3 [=]

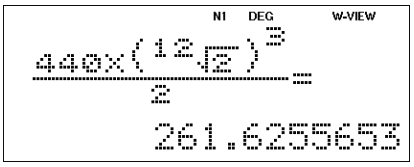



(2)

[ON/C] [a/b] 440 [×] [(] [2ndF] [x√‾]

12 [►] 2 [►] [)] [yx] 3 [►]

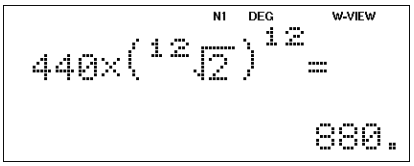
[►] 2 [=]




(3)

[ON/C] 440 [×] [(] [2ndF] [x√‾]

12 [►] 2 [►] [)] [yx] 12 [=]



# 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 |
|---|---|
| [2nd F] [$10^x$] 3 [=] | $10^3=$ 1'000. |
| [log] 1000 [=] | $\log 1000=$ 3. |
| [2nd F] [$\log_a x$] 3 [▶] 45 [=] | $\log_3(45)=$ 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 $8 \times 10^{13}$ joules. When this energy is converted to a magnitude,

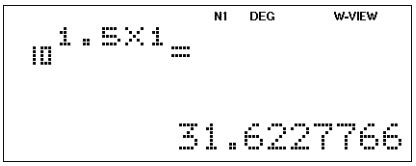
$$M = \frac{\log E - 4.8}{1.5}$$

holds. Find the magnitude $M$.

**Operation** **Display**

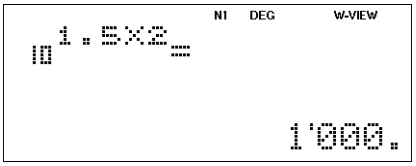
(1)

ON/C 2ndF $10^x$ 1.5 × 1 =




(2)

ON/C 2ndF $10^x$ 1.5 × 2 =

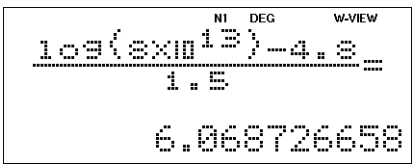



(3)

ON/C a/b log ( 8 × 2ndF

$10^x$ 13 ▶ ) − 4.8 ▶

1.5 =



# 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).

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

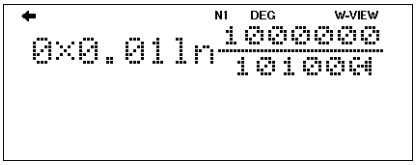
$$\approx \frac{p_1 V_1}{0.434} \log \frac{p_1}{p_2}$$

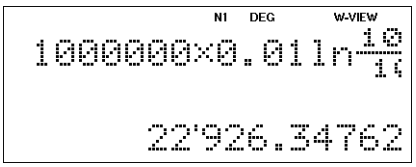
**Operation** **Display**

[ON/C] 1000000 [×] 0.01 [ln]

[a/b] 1000000 [▶] 101000

[=]



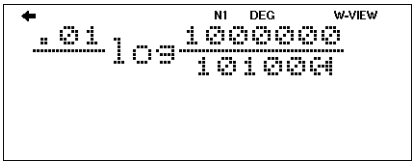



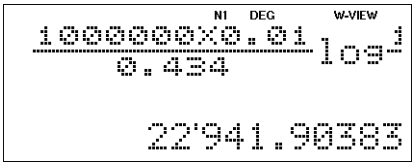

[ON/C] [a/b] 1000000 [×] 0.01 [▶]

0.434 [▶] [log] [a/b] 1000000

[▶] 101000

[=]



# Exponential, Logarithmic $10^x$ $\log_a x$

**<Example 3>** Find the pH of hydrochloric acid HCl at a concentration of $1.0 \times 10^{-8}$ mol/L

* pH = 7 (neutral), pH < 7 (acidic), pH > 7 (alkaline)

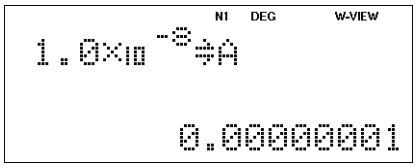
$$pH = -\log_{10}\left(a + \frac{\sqrt{a^2+4\times10^{-14}} - a}{2}\right)$$

**Operation** **Display**

Enter the value of *a*

ON/C 1.0 × 2ndF $10^x$ (–) 8

STO A




Calculate the pH

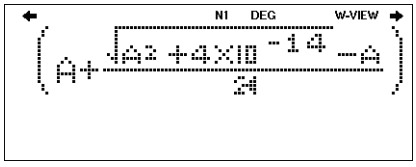
(–) 2ndF $\log_a x$ 10 ▶ ALPHA A

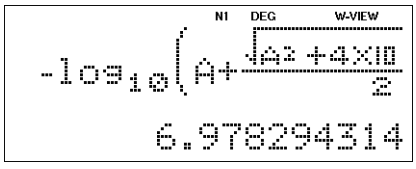
\+ a/b √ ALPHA A $x^2$ +

4 × 2ndF $10^x$ (–) 14 ▶

▶ – ALPHA A ▶ 2

=



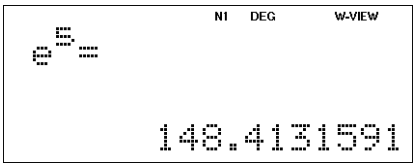
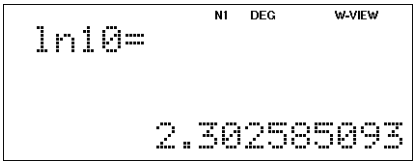



# e to the Power of x, Natural Logarithm [$e^x$] [ln]

[$e^x$] 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 |
|---|---|
| [2nd F] [$e^x$] 5 [=] |  |
| [ln] 10 [=] |  |

# Factorials $n!$

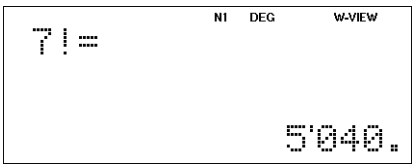
$n!$ The product of a given positive integer *n* multiplied by all the lesser positive integers from 1 to *n*-1 is indicated by *n*! and called the factorial of *n*.

**<Example 1>**

**Operation**

7 2nd F $n!$ =

**Display**




cf.
*n*! = 1 x 2 x 3 x …x *n*

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

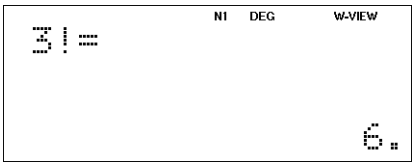
**3! = 3 x 2 x 1 = 6**

**Operation**

ON/C 3 2nd F $n!$

=

**Display**




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

# 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 1>**

| Operation | Display |
|---|---|
| 6 2ndF nPr 4 = | 6P4= 360. |
| 6 2ndF nCr 4 = | 6C4= 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.

# Permutations, Combinations $_nP_r$ $n!$ $_nC_r$

**<Example 2>** (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

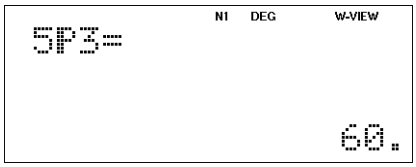
$$C = {}_5P_3 \div 3!$$

*This is written as $_5C_3$.

**Operation** **Display**

(1)

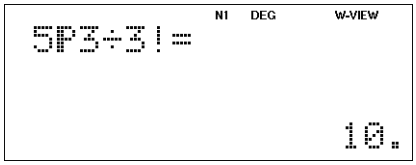
ON/C 5 2ndF $_nP_r$ 3 =



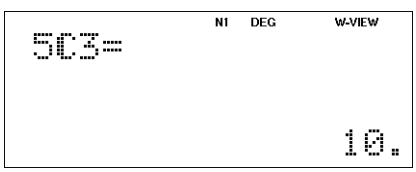

(2)

ON/C 5 2ndF $_nP_r$ 3 ÷

3 2ndF $n!$ =




ON/C 5 2ndF $_nC_r$ 3 =



# Permutations, Combinations $nCr$

**<Example 3>** 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** **Display**

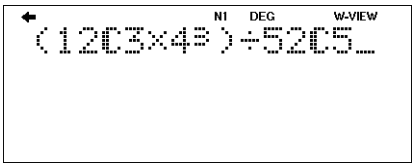
ON/C ( 13 × 4 2ndF $nCr$

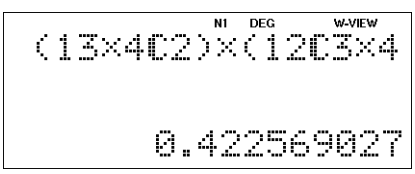
2 ) × ( 12 2ndF $nCr$

3 × 4 2ndF $x^3$ ) ÷

52 2ndF $nCr$ 5

= CHANGE



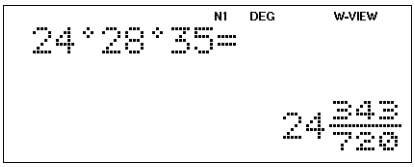
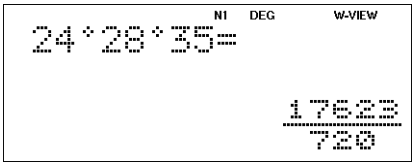
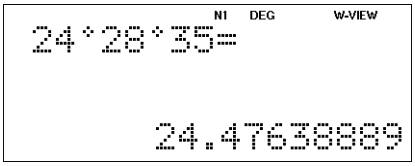
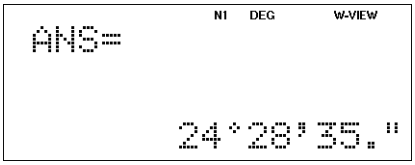



# Time Calculation ↔DEG D°M′S

↔DEG Converts a sexagesimal value displayed in degrees, minutes, seconds to decimal notation. Also, converts a decimal value to sexagesimal notation (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** 2nd F ↔DEG<br>Convert to decimal notation |  |
| CHANGE |  |
| CHANGE |  |
| 2nd F ↔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

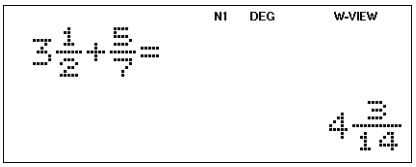
a/b Inputs proper or improper fractions which consist of a numerator and denominator.

ab/c Inputs a mixed fraction.

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

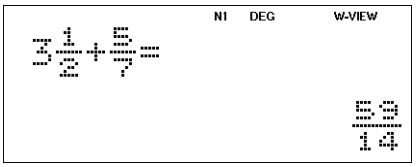
**Operation** **Display**

3 2ndF ab/c 1 ▶ 2 ▶
+ 5 a/b 7 =



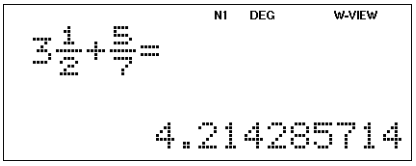

CHANGE

Convert to an improper fraction

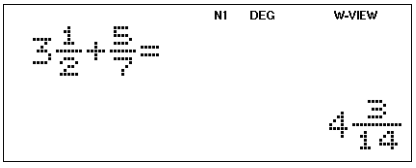



CHANGE

Convert to decimal notation




CHANGE




**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 — Stores displayed values in memories A~F, X, Y, M.

RCL — Recalls values stored in A~F, X, Y, M.

M+ — Adds the displayed value to the value in the independent memory M.

M− — Subtracts the displayed value from the value in the independent memory M.

A ~ F X Y — Temporary memories

M — Independent memory

**<Example 1>**

| Operation | Display |
|---|---|
| 0 STO M<br>(Enter 0 for M) | N1 DEG W-VIEW<br>0⇒M<br>0. |
| 25 × 27 M+ | N1 DEG W-VIEW<br>25×27M+<br>M<br>675. |
| 7 × 3 M+ | N1 DEG W-VIEW<br>7×3M+<br>M<br>21. |
| RCL M | N1 DEG W-VIEW<br>M=<br>M<br>696. |

**<Example 2>**

Calculates $/¥ at the designated exchange rate.

$1 = ¥110 ➡ ¥26,510 = $? $2,750 = ¥?

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

# Last Answer Memory ANS

**ANS** Recalls the last answer calculated by pressing =

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

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

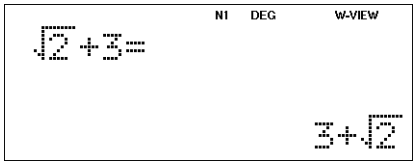
**Operation**

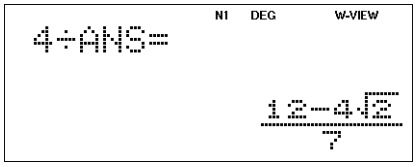
√ 2 ▶ + 3 =

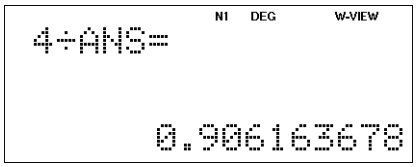
4 ÷ ALPHA ANS =

CHANGE

**Display**



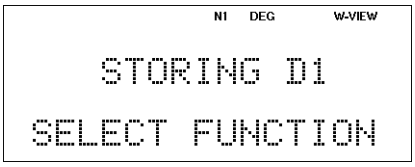
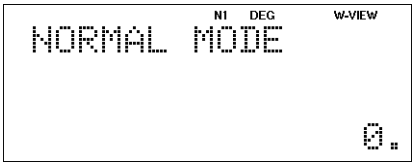
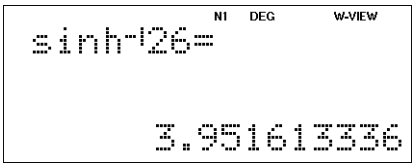



# User-Defined Functions D1 ~ D3

D1 ~ D3 Recall a function that was defined by the user.

**<Example>**

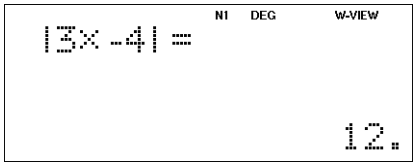
| Operation | Display |
|---|---|
| STO D1 |  |
| 2ndF hyp $\sin^{-1}$ |  |
| D1 26 = |  |

**APPLICATIONS:**
Functions that you have previously defined, including those using common 2nd Function buttons, can be stored in D1~ D3 for later use, thus saving time on keystrokes.

# Absolute Value abs

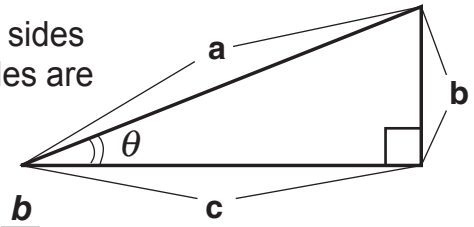
abs Returns an absolute value.

**<Example>**

| Operation | Display |
|---|---|
| 2nd F abs 3 × (−) 4 = (NEG) |  |

# 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:



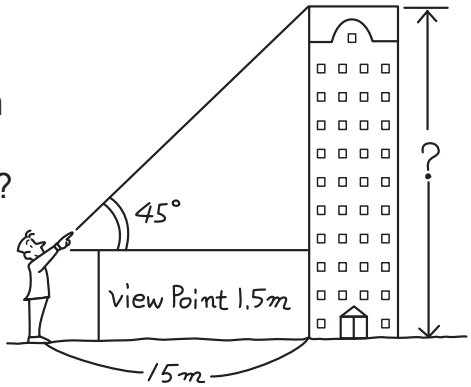

**[sin]** Calculates the sine of an angle. $\sin\theta = \frac{b}{a}$

**[cos]** Calculates the cosine of an angle. $\cos\theta = \frac{c}{a}$

**[tan]** Calculates the tangent of an angle. $\tan\theta = \frac{b}{c}$

**<Example 1>**

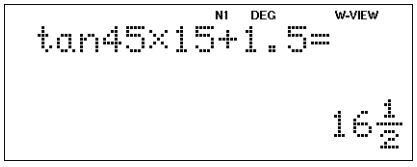
The angle from a point 15 meters from a building to the highest floor of the building is 45°. How tall is the building?



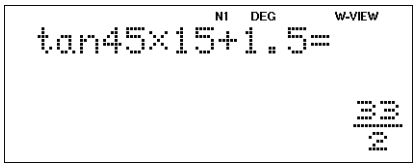

**[DEG mode]**

**Operation**

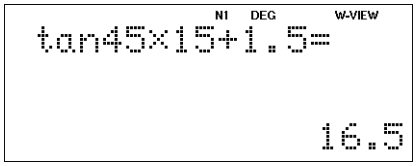
[tan] 45 [×] 15
[+] 1 [•] 5 [=]
View point




[CHANGE]




[CHANGE]

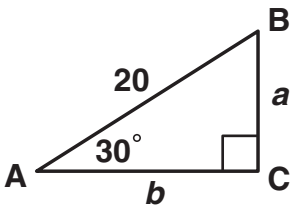


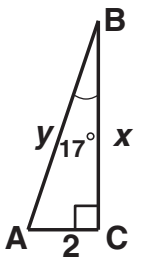

**APPLICATIONS:**
Trigonometric functions are useful in mathematics and various engineering calculations. They are often used in astronomical observations, civil engineering and in calculations involving electrical circuits, as well as in calculations for physics such as parabolic motion and wave motion.

# Trigonometric Functions sin cos tan

**<Example 2>**

Find the length of the side of the following triangle.




$a = 20 \sin 30$

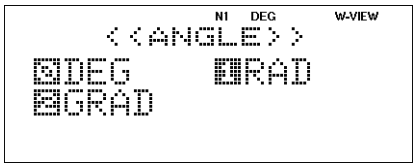
$b = 20 \cos 30$

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

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

**Operation** **Display**

SET UP 0 (DRG)




0 (DEG)

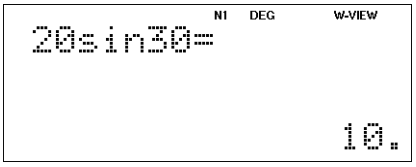
<Angle setting "∘" (DEG)>

**NOTE:**
In EL-W506T, Use 2nd F SET UP instead of SET UP.

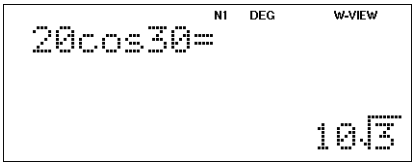
# Trigonometric Functions sin cos tan

ON/C

20 sin 30 =

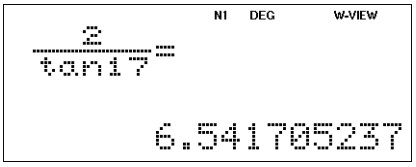



20 cos 30 =



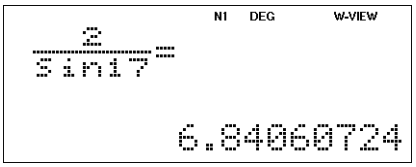

a/b 2 ▶ tan

17 =




a/b 2 ▶ sin

17 =



# Trigonometric Functions [sin]

**<Example 3>**

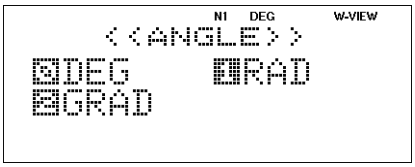
The instantaneous value $V$ of the AC voltage is expressed by the equation below.

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

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

| Operation | Display |
|---|---|
| [SET UP] [0] (DRG) |  |
| [1] (RAD) | |

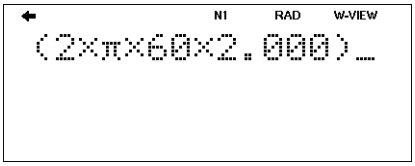


<Angle setting "rad" (RAD)>

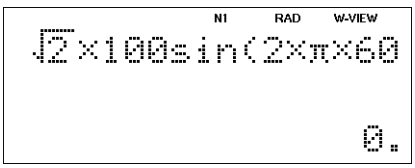
**NOTE:**
In EL-W506T, Use [2nd F] [SET UP] instead of [SET UP].

[ON/C] [√‾] 2 [▶] [×] 100

sin ( 2 × π × 60 × 2.000 )

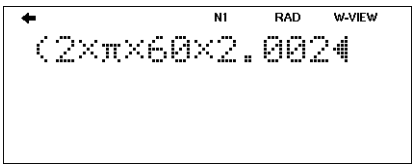
= 



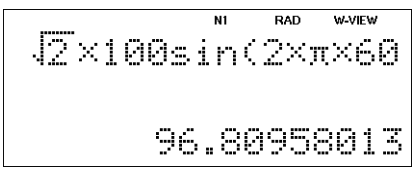




◀ ◀ [BS] 2

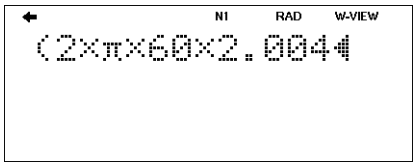
= 



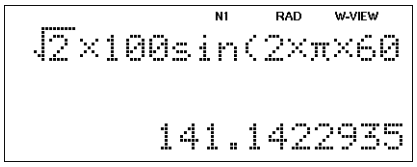


# Trigonometric Functions sin

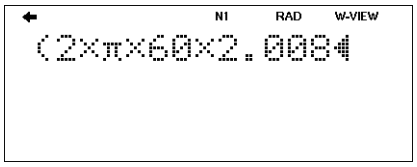
◀ ◀ BS 4



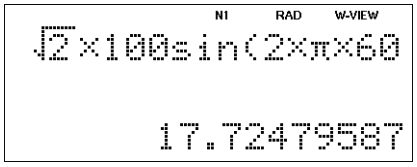

=



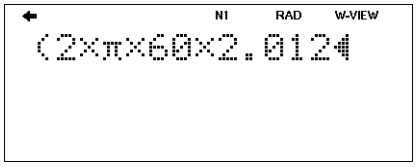

◀ ◀ BS 8



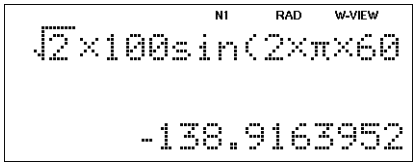

=



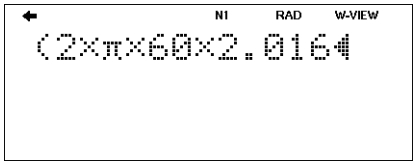

◀ ◀ BS BS 12



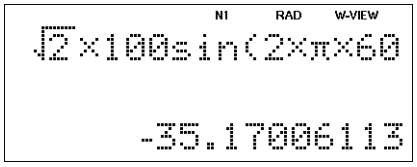

=




◀ ◀ BS BS 16

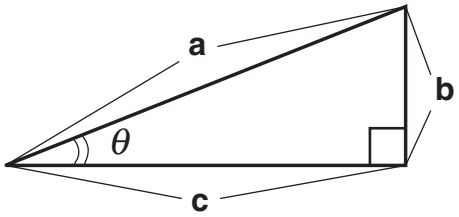



=



# 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;



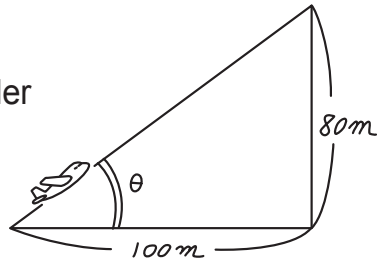

**$\sin^{-1}$** (arc sine) Determines an angle based on the ratio *b*/*a* of two sides of a right triangle. $\theta = \sin^{-1}\frac{b}{a}$

**$\cos^{-1}$** (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 airplane climb in order to climb 80 meters in 100 meters?



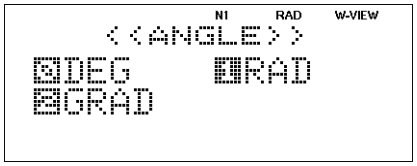

**Operation**

SET UP 0 (DRG)

0 (DEG)

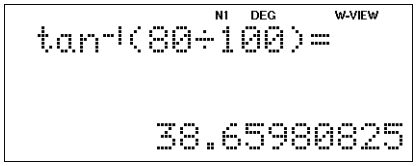
<Angle setting "∘" (DEG)>

**Display**




**NOTE:**
In EL-W506T, Use 2nd F SET UP instead of SET UP .

2nd F $\tan^{-1}$ ( 80 ÷ 100 ) =



# 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.

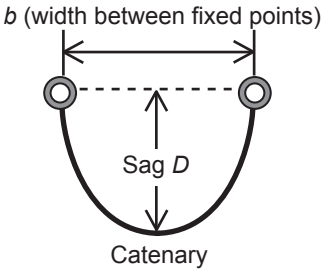
**APPLICATIONS:**
Hyperbolic and arc hyperbolic functions are very useful in electrical engineering and physics.

# Hyperbolic Functions [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.

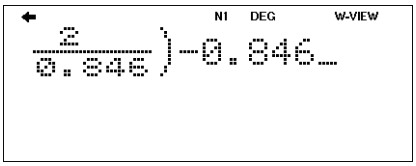
$$L = 2a\sinh\frac{b}{2a}$$

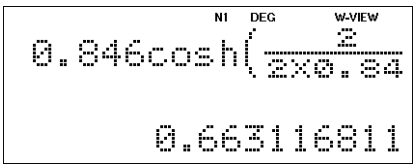
When $a = 0.846$ and $b = 2$, find the rope sag *D* and the rope length *L*.

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

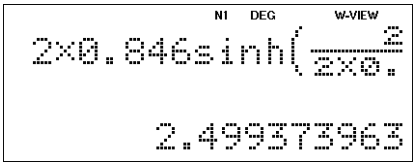
**Operation** **Display**

[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 Functions hyp tan

**(This example is for EL-W506T only.)**

**<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 |

**NOTE:**
This example is solved by the Simulation calculation (ALGB).
EL-W506T has the Simulation calculation (ALGB).
This function is convenient for repeated calculations using varying values of *X*.

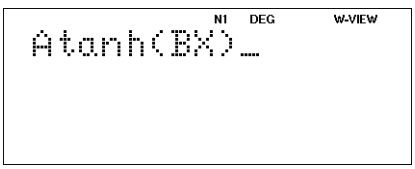
1. Enter *A*tan*h*(*BX*) (use the characters *A*, *B*, and *X* to enter)

**[DEG mode]**

**Operation**

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

**Display**

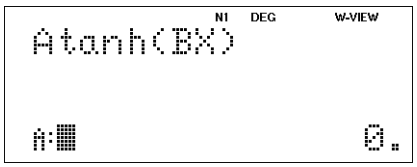


# Hyperbolic Functions hyp tan

2. Enter the Simulation calculation.

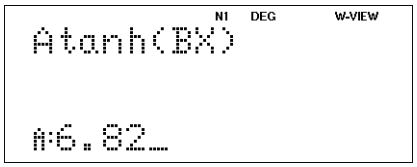
2nd F ALGB

<Simulation calculation>




3. Enter the value of *A*

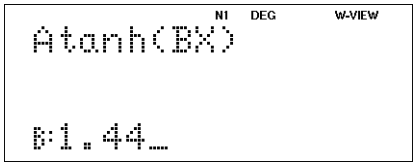
**6.82** =




(If 6.82 appears, press only the = key)

4. Enter the value of *B*

**1.44** =

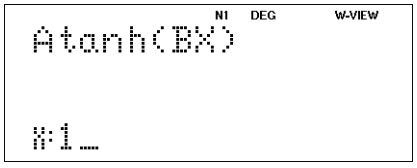



(If 1.44 appears, press only the = key)

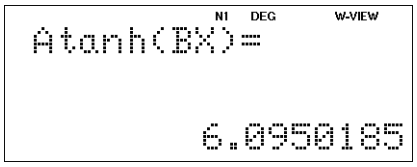
5. Enter the value of *X*

For example,

**1** =




6. The answer is obtained.



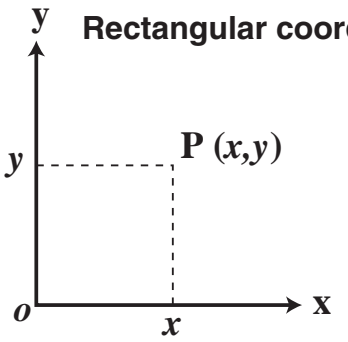

Repeat 2 to 6

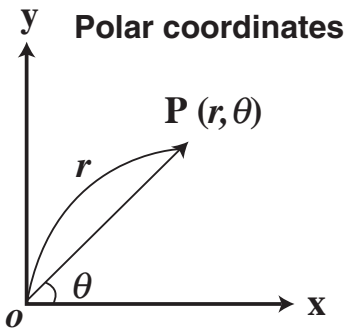
# Coordinate Conversion →rθ →xy (x,y)'

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

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

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



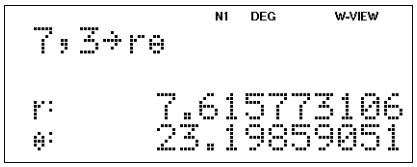




**<Example>** Determine the polar coordinates (r, $\theta$) when the rectangular coordinates of Point P are ($x$ = 7, $y$ = 3).

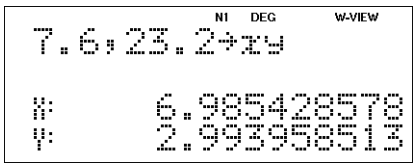
**[DEG mode]**

**Operation**

7 (x,y)' 3 2ndF →rθ




7.6 (x,y)' 23.2 2ndF →xy




**APPLICATIONS:**
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. "BIN" appears.

**[→PEN]** Converts to the pental system. "PEN" appears.

**[→OCT]** Converts to the octal system. "OCT" appears.

**[→HEX]** Converts to the hexadecimal system. "HEX" appears.

**[→DEC]** Converts to the decimal system. "BIN", "PEN", "OCT", and "HEX" 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_<br>HEX |
| [2ndF] [→BIN] | 1AC→BIN<br>BIN 110101100 |
| [2ndF] [→PEN] | ANS→PEN<br>PEN 3203 |
| [2ndF] [→OCT] | ANS→OCT<br>OCT 654 |
| [2ndF] [→DEC] | ANS→DEC<br>428. |

**<Example 2>** 1011 AND 101 = (BIN) →DEC

| Operation | Display |
|---|---|
| [ON/C] [2ndF] [→BIN] 1011 [AND] | 1011AND101=<br>BIN 1 |
| 101 [=] | |
| [2ndF] [→DEC] | ANS→DEC<br>1. |

# Differentiation calculation [d/dx] [x]

**(This example is for EL-W506T only.)**

**<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.

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

**Operation** **Display**

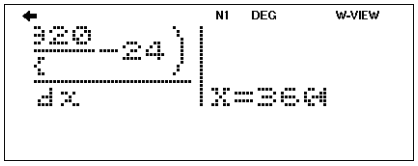
[ON/C] [(−)] [a/b] 360 [▶] 48

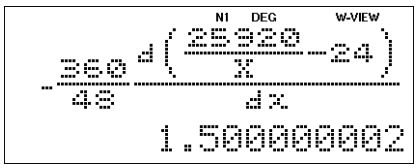
[▶] [ALPHA] [d/dx] [a/b] 25920

[▶] [ALPHA] [x] [▶] [−] 24

[▶] 360

[=]

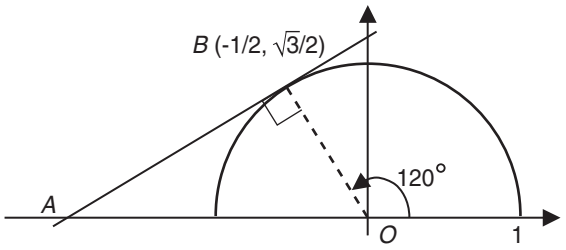


# Differentiation calculation $d/dx$ $x$

**(This example is for EL-W506T only.)**

**<Example 2>**



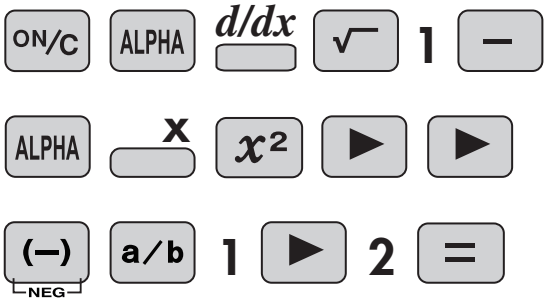

The semicircle above is given by the equation

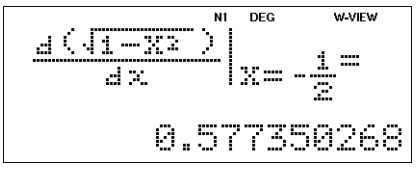
$$y = \sqrt{1 - x^2}$$

Find the slope of the tangent $AB$ at point $B$ (-1/2, $\sqrt{3}$/2) on the semicircle.

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

**Operation** **Display**



# Integration calculation $\int dx$ X

**(This example is for EL-W506T only.)**

**<Example 1>**

Let the demand curve of the overall market be $D$ = 3000 - 10$P$, the supply curve be $S$ = 20$P$, 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**

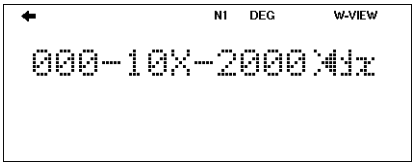
(1)

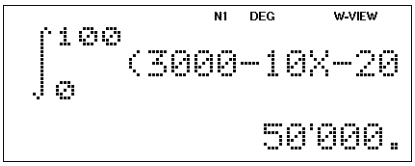
ON/C ALPHA $\int dx$ 0 ▶ 100

▶ ( 3000 − 10

ALPHA X − 2000 )

=



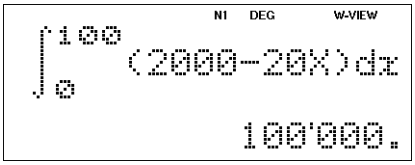




(2)

ON/C ALPHA $\int dx$ 0 ▶ 100

▶ ( 2000 − 20

ALPHA X ) =



# Integration calculation $\int dx$ x

(3)

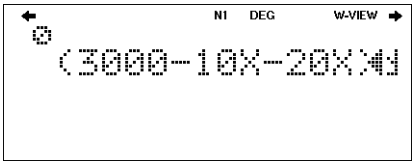
ON/C ALPHA $\int dx$ 0 ▶ 100

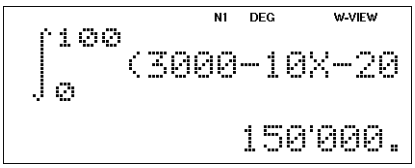
▶ ( 3000 − 10

ALPHA x − 20 ALPHA

x )

=

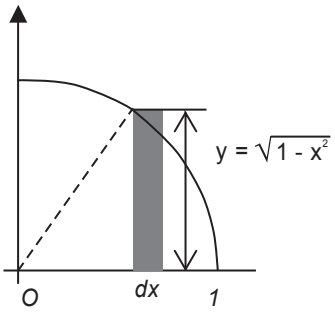


# Integration calculation $\int dx$ X

**(This example is for EL-W506T only.)**

**<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°.

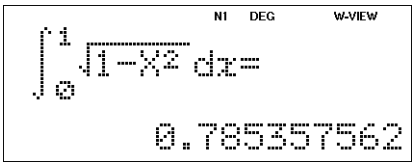
$\int_0^1 \sqrt{1 - x^2}\, dx$

**Operation** **Display**

ON/C ALPHA $\int dx$ 0 ▶ 1

▶ √ 1 − ALPHA X

$x^2$ =



# Simultaneous Calculation MODE

**(This example is for EL-W506T only.)**

### <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 300 dollars/unit and the selling price of product *Y* is 200 dollars/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)

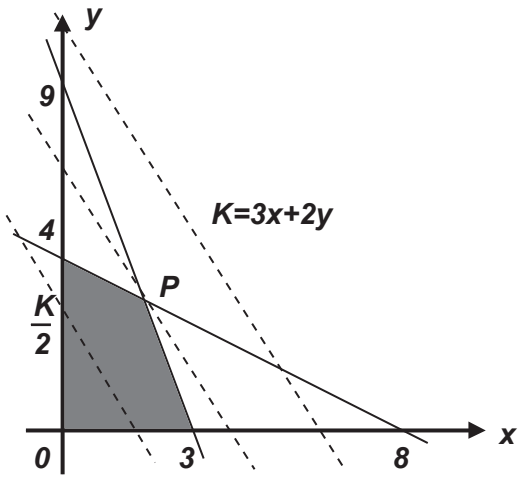
If the quantities produced of each product are *x* and *y*, the sales *K* can be expressed as

$$K = 3x + 2y$$

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 100) dollars (when $x = 2$ units and $y = 3$ units)**

# Simultaneous Calculation MODE

(1) Solve the following simultaneous equations.
$3x + y = 9$
$x + 2y = 8$

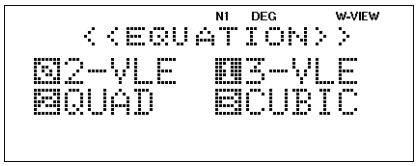
(2) Use the result of (1) to find the following value.
$K = 3x + 2y$

**Operation** **Display**

(1)

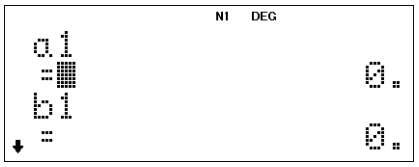
Set the mode to Equation

MODE 4 **(EQUATION)**




<Equation mode>

0 **(2-VLE)**



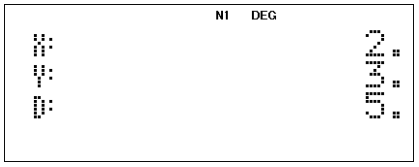

<Simultaneous linear equations in two unknowns>

Enter the coefficients

a1 = 3 , b1 = 1 , c1 = 9
a2 = 1 , b2 = 2 , c2 = 8

3 ENTER 1 ENTER 9 ENTER

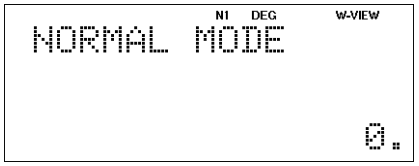
1 ENTER 2 ENTER 8 ENTER



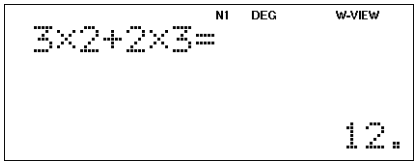

(2)

Set the mode to Normal

MODE 0 **(NORMAL)**




3 × 2 + 2 × 3 =



# Simultaneous Calculation MODE

**(This example is for EL-W506T only.)**

### <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: $5x + x = 2z$
Number of O: $x + 6 = 2y + z$

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**

Set the mode to Equation

MODE **4** **(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

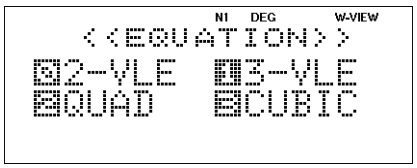
**2** ENTER **(–)** NEG **1** ENTER **0** ENTER **0** ENTER

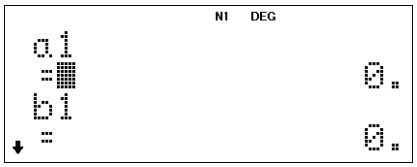
**6** ENTER **0** ENTER **(–)** NEG **2** ENTER **0** ENTER

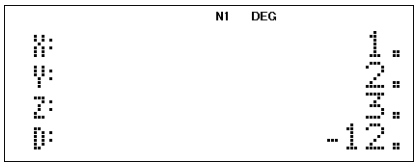
**1** ENTER **(–)** NEG **2** ENTER **(–)** NEG **1** ENTER **(–)** NEG **6**

ENTER

**Display**



# Polynomial equation MODE

## (This example is for EL-W506T only.)

### <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 $x$:

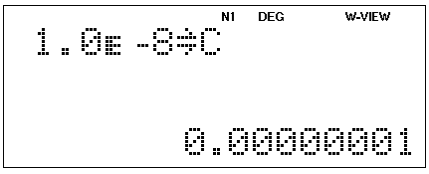
$$x^2 - cx - K_w = 0$$

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.

$$pH = - \log x \ (x>0)$$

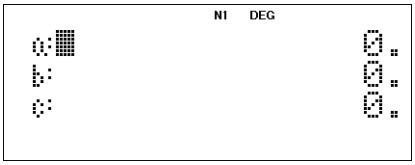
| Operation | Display |
|---|---|
| (1) | |
| Save constants | |
| MODE 0 (NORMAL) | |
| 1.0 Exp (–) 14 | |
| STO B | |
| 1.0 Exp (–) 8 |  |
| STO C | |

# Polynomial equation MODE

Set the mode to Equation

MODE 4 (EQUATION) 2 (QUAD)

<Quadratic equation>

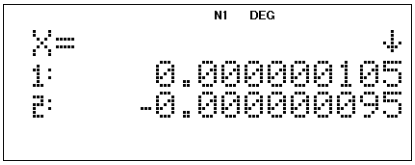



Solve the equation (enter coefficients a, b, c)

1 ENTER

(−) NEG ALPHA C ENTER

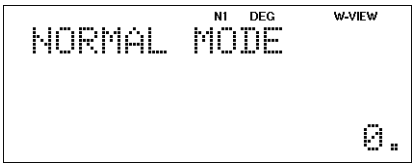
(−) NEG ALPHA B ENTER



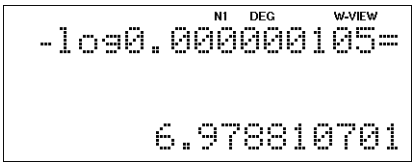

(2)

Set the mode to Normal

MODE 0 (NORMAL)




(−) NEG log 0.000000105




=

# Polynomial equation MODE

**(This example is for EL-W506T only.)**

**<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 $x$:

$$x^3 + K_a x^2 - (cK_a + K_w)x - K_a K_w = 0$$

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)

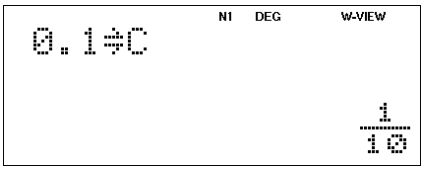
Save constants

MODE 0 (NORMAL)

2.75 Exp (−) NEG 5 STO A

1.0 Exp (−) NEG 14 STO B

0.1 STO C

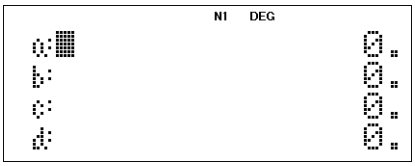


# Polynomial equation MODE

Set the mode to Equation

MODE 4 (EQUATION) 3 (CUBIC)

<Cubic equation>




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

1 ENTER

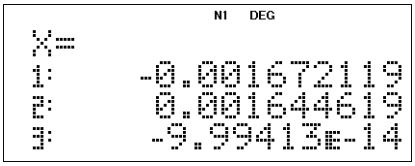
ALPHA A ENTER

(–) NEG ( ALPHA C ALPHA A

+ ALPHA B ) ENTER

(–) NEG ALPHA A ALPHA B

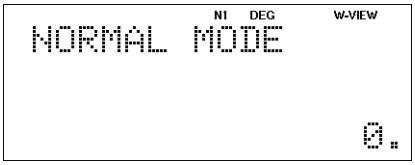
=




(2)

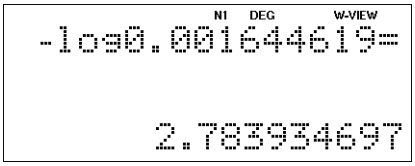
Set the mode to Normal

MODE 0 (NORMAL)




ON/C (–) NEG log 0.001644619

=



# Complex Calculation [MODE] [→xy] [→rθ] [i]

**(This example is for EL-W506T only.)**

**<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.

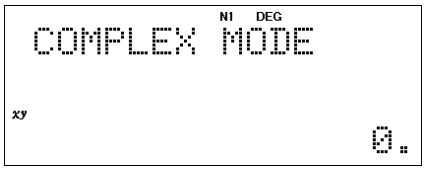
Circuit impedance = Value of polar coordinate $r$

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 |
|---|---|

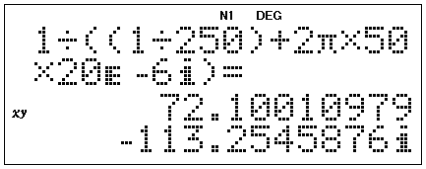
[MODE] [3] (COMPLEX)

<Complex mode>



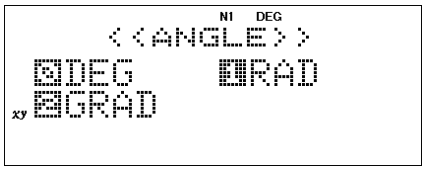

[2nd F] [→xy] (Rectangular coordinates)

[1] [÷] [(] [(] [1] [÷] [250]
[)] [+] [2] [π] [×] [50] [×]
[20] [Exp] [(–)] [6] [i] [)] [=]

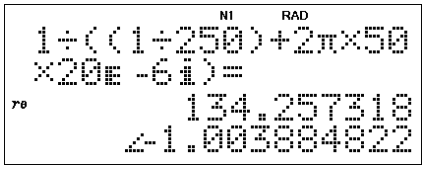



[2nd F] [SET UP] [0] (DRG)

[1] (RAD) (Angle units: RAD)




[2nd F] [→rθ] (Polar coordinates)



# Complex Calculation MODE →xy →rθ i

**(This example is for EL-W506T only.)**

**<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 |
|---|---|

MODE 3 (COMPLEX)

<Complex mode>

ON/C 2nd F →xy (rectangular coordinates)

120 + 2 π × 60 ×

4 × i + 1 ÷ (

2 π × 60 × 3 Exp

(–) NEG 6 i ) =

```
                    N1      RAD
 120+2π×60×4×i+1÷
 (2π×60×3E -6i)=
                          120.
xy      +623.7703454i
```

2nd F SET UP 0 (DRG)

0 (DEG) (Angle units: DEG)

2nd F →rθ (Polar coordinates)

```
                    N1      DEG
 120+2π×60×4×i+1÷
 (2π×60×3E -6i)=
                      635.2081894
rθ                  ∠79.110561
```

# Statistics Functions

MODE (x,y)' DATA INS-D STAT

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.

(x,y)' Splits data used for X and FRQ data input (or X, Y, and FRQ data input).

DATA Close/display the input table.

INS-D Insert a line in the input table for data insertion.

STAT Statistical values can be calculated from the STAT menu.

## DATA INPUT FOR 1-VARIABLE STATISTICS

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

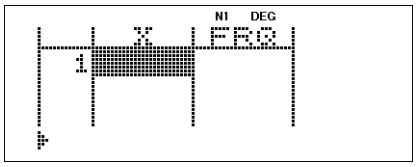
**Data table 1**

| **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 |

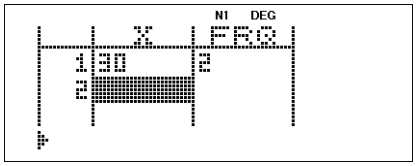
**Operation** **Display**

MODE 1 0

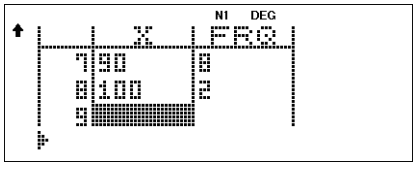
Select single-variable statistics mode (The input table is displayed.)




30 (x,y)' 2 ENTER




100 (x,y)' 2 ENTER



# “ANS” FOR 1-VARIABLE STATISTICS

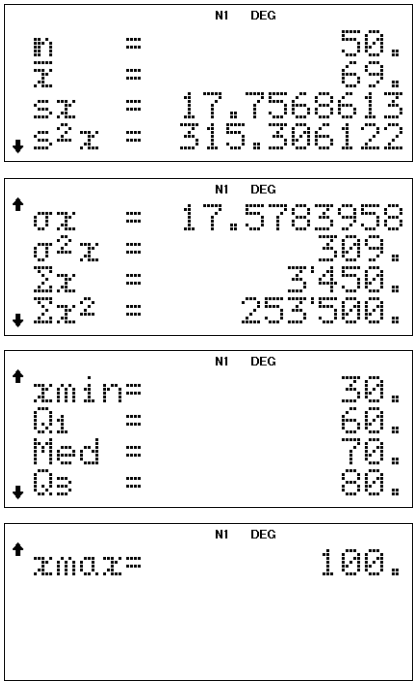
Let’s check the results based on the previous data.

**Operation** **Display**

DATA (Close the input table.)

ALPHA STAT 0

Calculates Statistical values.




For examples,

| | | |
|---|---|---|
| $n$ | = 50 | (number of input data) |
| $\bar{x}$ | = 69 | (average value) |
| $sx$ | = 17.7568613 | (standard deviation) |
| $\sigma x$ | = 17.5783958 | (standard deviation of the population) |
| $\Sigma x$ | = 3450 | (sum of the data) |

**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).

**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>

| 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 0

2nd F CA

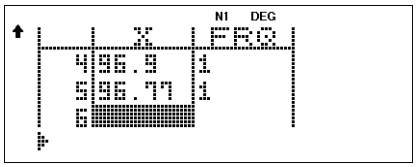

DATA (Display the input table.)

97.27 ENTER

96.83 ENTER

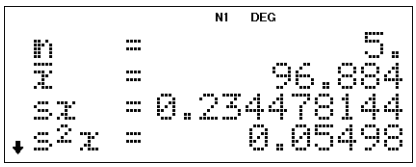
...

96.77 ENTER

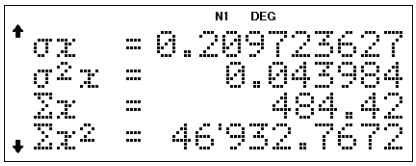



DATA (Close the input table.)

ALPHA STAT 0




▼




Average = 96.884

Standard deviation = 0.209723627

# DATA CORRECTION

Move the cursor ( ▲ ▼ ◄ ► ) to the data that you want to correct, enter the numeric value, and press ENTER.

- To insert a line in front of the cursor position, press ALPHA INS-D.
- To delete the entire line where cursor is positioned, press 2nd F DEL.

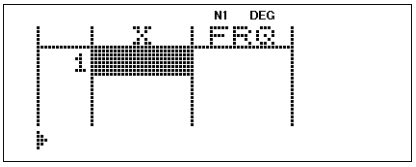
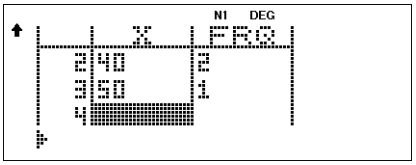
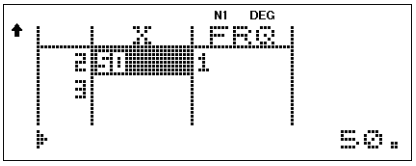
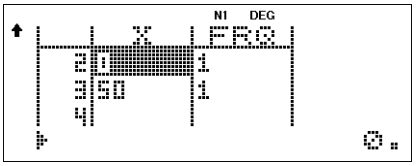
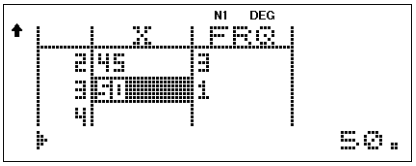
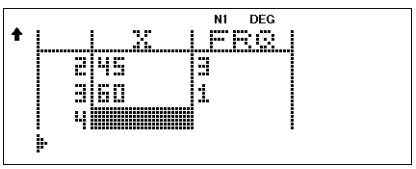
**<Example 3>**

**Data table 2**

X: 30, 40, 40, 50

⬇

X: 30, 45, 45, 45, 60

| Operation | Display |
|---|---|
| MODE 1 0<br>2nd F CA DATA |  |
| 30 ENTER<br>40 (x,y)' 2 ENTER<br>50 ENTER |  |
| ▲ ▲ 2nd F DEL |  |
| ALPHA INS-D |  |
| 45 (x,y)' 3 ENTER |  |
| 60 ENTER |  |

# DATA INPUT FOR 2-VARIABLE STATISTICS

**<Example 4>** 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**

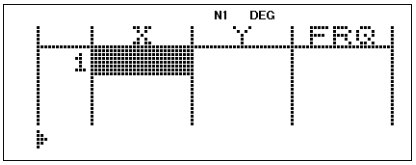
| | Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| x | Average temperature | 6.2 | 7.0 | 6.8 | 8.7 | 7.9 | 6.5 | 6.1 | 8.2 |
| y | Date blossoms bloom | 13 | 9 | 11 | 5 | 7 | 12 | 15 | 7 |

**Operation**

MODE 1 1

Select two-variable statistics mode and linear regression calculation in sub-mode. (The input table is displayed.)

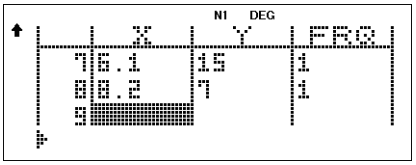
**Display**




6.2 (x,y)' 13

⋮

8.2 (x,y)' 7 ENTER

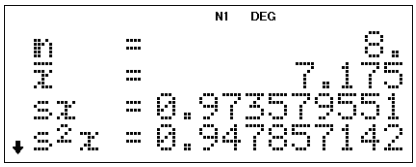


# “ANS” FOR 2-VARIABLE STATISTICS

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

**Operation** **Display**

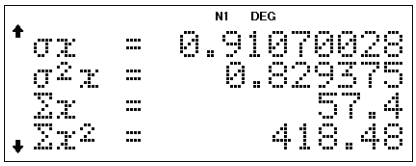
DATA (Close the input table.)




ALPHA STAT 0

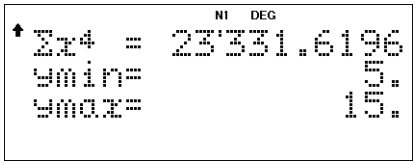
Calculates Statistical values.

▼




⋮

▼




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

For examples,

| | | |
|---|---|---|
| $n$ | = 8 | (Total count of data) |
| $\bar{x}$ | = 7.175 | (Average for data *x*) |
| $sx$ | = 0.973579551 | (Standard deviation for data *x*) |
| $\sigma x$ | = 0.91070028 | (Standard deviation of the population for data *x*) |
| $\Sigma x$ | = 57.4 | (Sum of data *x*) |
| $\Sigma x^2$ | = 418.48 | (Sum of data *x* raised to the second power) |
| $\bar{y}$ | = 9.875 | (Average for data *y*) |
| $sy$ | = 3.44082631 | (Standard deviation for data *y*) |
| $\sigma y$ | = 3.2185983 | (Standard deviation of the population for data *y*) |
| $\Sigma y$ | = 79 | (Sum of data *y*) |
| $\Sigma y^2$ | = 863 | (Sum of data *y* raised to the second power) |
| $\Sigma xy$ | = 544.1 | (Sum of the product of data *x* and 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.

## <Example 5>

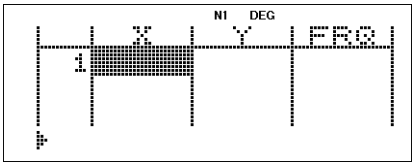
| Spring extension $x$ [m] | Force $F$ [N] |
|---|---|
| 0.028 | 0.2 |
| 0.073 | 0.39 |
| 0.118 | 0.6 |
| 0.16 | 0.77 |
| 0.207 | 1 |

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 1

2nd F CA DATA

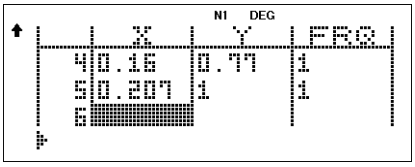



0.028 (x,y)' 0.20 ENTER

0.073 (x,y)' 0.39 ENTER

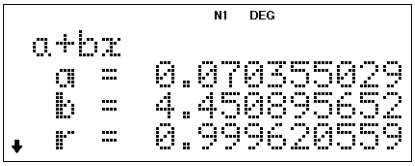
...

0.207 (x,y)' 1.00 ENTER




DATA (Close the input table.)

ALPHA STAT 1



## <Example 6>

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.

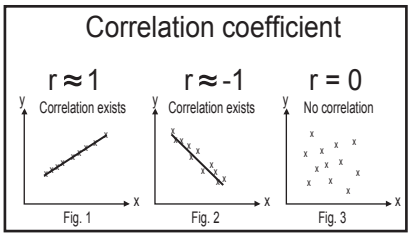
(Room temperature 25 °C, hot water temperature 92 °C)

| 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.

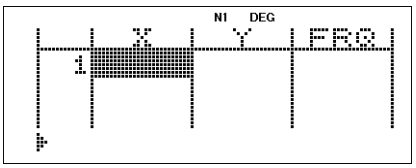
| x | y |
|---|---|
| 0 | 67 |
| 4 | 37 |
| 8 | 21 |
| 12 | 13 |
| 16 | 7 |
| 20 | 4 |
| 24 | 2 |
| 28 | 2 |
| 32 | 1 |
| 36 | 1 |
| 40 | 1 |




**Operation** **Display**

MODE 1 3

2nd F CA DATA

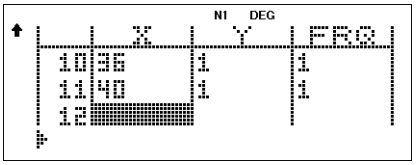



0 (x,y) 67 ENTER

4 (x,y) 37 ENTER

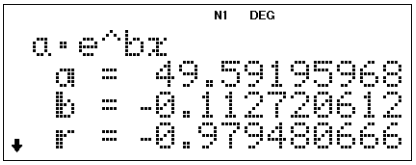
...

40 (x,y) 1 ENTER




DATA (Close the input table.)

ALPHA STAT 1

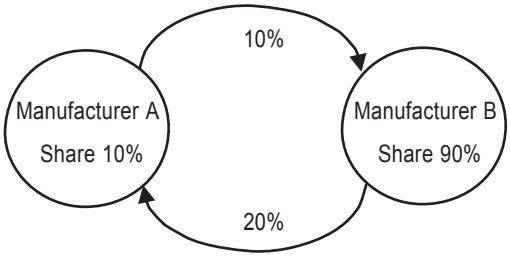


# Matrix Calculation MODE MATH

**(This example is for EL-W506T only.)**

**<Example>**

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 2 years.




**Answer**

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

$a_1 = 0.9a_0 + 0.2b_0$
$b_1 = (1-0.9)a_0 + (1-0.2)b_0$

Thus, $a_1$ and $b_1$ are
$a_1 = 0.9a_0 + 0.2b_0$
$b_1 = 0.1a_0 + 0.8b_0$

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

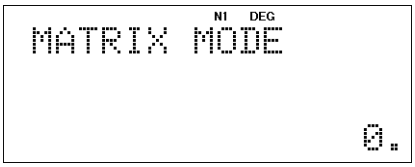
$$A^2 = \begin{bmatrix} 0.83 & 0.34 \\ 0.17 & 0.66 \end{bmatrix}$$ : This is equal to mat$A^2$.

# Matrix Calculation [MODE] [MATH]

**Operation** **Display**

Set the mode to Matrix

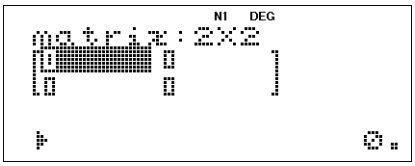
[MODE] [5] **(MATRIX)** Matrix mode




Enter matA

[MATH] [1] **(EDIT)** [ENTER]

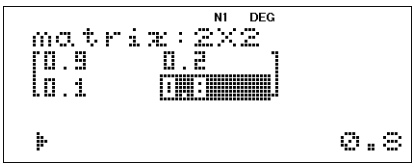
<2 x 2 Matrix>




**0.9** [ENTER] **0.2** [ENTER]

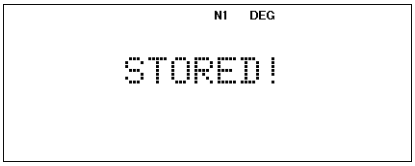
**0.1** [ENTER] **0.8** [ENTER]

<Enter numeric values>




[ON/C] [MATH] [3] **(STORE)** [0]

<0: Save to matA>

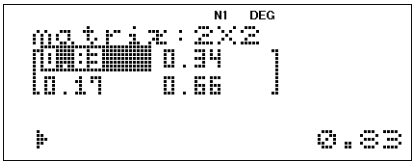



Calculate

[ON/C] [MATH] [0] **(MATRIX)** [0]

[$x^2$] [=]

<Calculate the square>




**Find the shares of manufacturers A and B after 2 years.**

[ON/C] **0.83** [×] **10** [+]

**0.34** [×] **90** [=] (A: 38.9%)

**0.17** [×] **10** [+]

**0.66** [×] **90** [=] (B: 61.1%)

SHARP

SHARP CORPORATION


19BSC39E1