If you are accessing from **Europe**, please visit: [http://www.sharp-calculators.com/](http://www.sharp-calculators.com/)
You can get the Guide book of the latest model.

If you are accessing from **U.S.A.**, please visit: [https://sharpcalculators.com/](https://sharpcalculators.com/)
You can get the Guide book of the latest model.
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</tr>
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<td>( \frac{d}{dx} )</td>
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How to Operate

Read Before Using

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

1. KEY LAYOUT

Mode key
This calculator can operate in three different modes as follows.

**Example**

[NORMAL mode]
- Mode = 0; normal mode for performing normal arithmetic and function calculations.

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

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

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

2nd function
Written in orange above the ON/C key

ON/C, OFF key
Direct function

ON/C

<Power on>

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

<Power off>

SD: Single variable statistic calculation
LINE: Linear regression calculation
QUAD: Quadratic regression calculation
E_EXP: Euler Exponential regression calculation
LOG: Logarithmic regression calculation
POWER: Power regression calculation
INV: Inverse regression calculation
EXP: Exponential regression calculation
MATH: Math drill
TABLE: Multiplication table drill
2. RESET SWITCH

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

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

3. DISPLAY PATTERN

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

4. DISPLAY FORMAT AND DECIMAL SETTING FUNCTION

For convenient and easy operation, this model can be used in one of five display modes. The selected display status is shown in the lower left part of the display (Format Indicator).

Note: If more 0's (zeros) than needed are displayed when the ON/C key is pressed, check whether or not the calculator is set to a Special Display Format.

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

<Example>
Let’s compare the display result of 
\([10000 \div 8.1 =]\) in each display format.

(specifies normal mode)

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

- NORM1: \(0.000000001 \leq x \leq 9999999999\)
- NORM2: \(0.01 \leq x \leq 9999999999\)

10000 \(\div\) 8.1 \(=\)

\[
\begin{array}{c}
\text{Initial display} \\
\text{DEG} \\
\text{W-VIEW} \\
\text{NORM MODE} \\
\text{0,} \\
\text{10000} \div 8.1 = \\
\text{DEG} \\
\text{W-VIEW} \\
\text{10000} \div 8.1 = \\
\end{array}
\]
5. EXPONENT DISPLAY

The distance from the earth to the sun is approx. 150,000,000 (1.5 x 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 x 10^-19 coulombs).

\[ 0.32 \div 1.6 \text{ Exp} 19 = \]

\[ 2 \times 10^{-20} \]
6. ANGULAR UNIT

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

**Degrees (DEG is shown at the top of the display)**
A commonly used unit of measure for angles. The angular measure of a circle is expressed as 360°.

**Radians (RAD is shown at the top of the display)**
Radians are different from degrees and express angles based on the circumference of a circle. 180° is equivalent to \( \pi \) radians. Therefore, the angular measure of a circle is 2\( \pi \) 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:

\[
90° (DEG) = \frac{\pi}{2} (RAD) = 100 (GRAD) = \]

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>SET UP 0 0</td>
<td><img src="image" alt="Normal Mode" /></td>
</tr>
<tr>
<td>90 2ndF DRG</td>
<td><img src="image" alt="90 RAD" /></td>
</tr>
<tr>
<td>2ndF DRG</td>
<td><img src="image" alt="ANS+GRAD" /></td>
</tr>
<tr>
<td>2ndF DRG</td>
<td><img src="image" alt="ANS+DEG" /></td>
</tr>
</tbody>
</table>
6. ANGULAR UNIT

Operation Display

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

Degrees (DEG is shown at the top of the display)
A commonly used unit of measure for angles. The angular measure of a circle is expressed as 360 °.

Radians (RAD is shown at the top of the display)
Radians are different from degrees and express angles based on the circumference of a circle. 180 ° is equivalent to \( \frac{\pi}{2} \) radians. Therefore, the angular measure of a circle is \( 2\pi \) 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:

\[
\begin{align*}
\text{90° (DEG)} &= \frac{\pi}{2} \text{ (RAD)} = 100 \text{ (GRAD)} \\
\end{align*}
\]

Check to confirm 90 degrees equalling \( \frac{\pi}{2} \) radians equalling 100 grads. (\( \pi = 3.14159 \... \)).

7. 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, coefficients in 3-variable linear equations and statistics, as well as values stored in the independent memory in normal mode, are not erased.

**OFF**

Turns the calculator off.

**CA**

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

**△ ▼**

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

**◄ ►**

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

0 to 9 Numeric keys for entering data values.

- Decimal point key. Enters a decimal point.

- Enters the minus symbol.
  The subtraction key \(\text{\textasciitilde}\) is not used for entering negative numbers.

- Pressing \(\pi\) automatically enters the value for \(\pi\) (3.14159...).
  The constant \(\pi\), used frequently in function calculations, is the ratio of the circumference of a circle to its diameter

\[
\pi \quad \text{EL-W506X/EL-W516X/EL-W506 only}
\]

- 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 \(\times \pi\); therefore,
\[1.496 \times 10^8 \times 2 \times \pi\]

\[
\begin{array}{c|c|l}
\text{Operation} & \text{Display} \\
\hline
1.496 \text{Exp} 8 \times 2 \times \pi & 1.496\times8\times2\times\pi= \\
& 939'964'522. \\
\end{array}
\]
Random Key

**RANDOM**

Generates random numbers.

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

**<Example>**

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

**[Random Dice]**

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

**[Random Coin]**

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

**[Random Integer]**

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

**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)

\[
\begin{align*}
5 \div 9 &= 0.6 \quad \text{(internally, 0.5555\ldots)} \\
\times 9 &= 5.0
\end{align*}
\]

Rounded calculation (MDF)

\[
\begin{align*}
5 \div 9 &= 0.6 \quad \text{(internally, 0.5555\ldots)} \\
\text{(In W-View mode, press to show the answer in decimal.)}
\end{align*}
\]

\[
\begin{align*}
\text{2ndF MDF} \quad (\text{internally, 0.6}) \\
\times 9 &= 5.4
\end{align*}
\]

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

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

1) $125$ increased by $10\%\ldots137.5$

$$125 + 10 \div 2 \div \%$$

$$125+10\% = 137.5$$

2) $125$ reduced by $20\%\ldots100$

$$125 - 20 \div 2 \div \%$$

$$125-20\% = 100$$

3) $15\%$ of $125\ldots18.75$

$$125 \times 15 \div 2 \div \%$$

$$125\times15\% = 18.75$$

4) When $125$ equals $5\%$ of $X$, $X$ equals $\ldots2500$

$$125 \div 5 \div \%$$

$$125\div5\% = 2500$$
Inverse, Square, Cube, xth Power of y, Square Root, Cube Root, xth Root of y

$\frac{1}{x}$ Calculates the inverse of the value on the display.

$x^2$ Squares the value on the display.

$x^3$ Cubes the value on the display.

$y^x$ Calculates exponential values.

$\sqrt{}$ Calculates the square root of the value on the display.

$3\sqrt{}$ Calculates the cube root of the value on the display.

$x\sqrt{}$ Calculates the $x^{th}$ root of $y$.

<Example>

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
</table>
| $2 \times 2 \times 2 \times 2 = $ | \[
\begin{array}{c}
2\times2\times2\times2= \\
16.
\end{array}
\] |
| $2 \ y^x \ 4 = $ | \[
\begin{array}{c}
2^4= \\
16.
\end{array}
\] |
| $4 \ \text{2nd F} \ 16 = $ | \[
\begin{array}{c}
\sqrt[4]{16} = \\
2.
\end{array}
\] |
<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$^2$.

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

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/C</td>
<td></td>
</tr>
<tr>
<td>2ndF</td>
<td>$3\sqrt{}$</td>
</tr>
<tr>
<td>$\pi$</td>
<td></td>
</tr>
<tr>
<td>$\times$</td>
<td>20</td>
</tr>
<tr>
<td>$\pi$</td>
<td></td>
</tr>
</tbody>
</table>

16 $\times$ 9550 $\Rightarrow$ 2ndF

$13.44769432$

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

Use $\pi$ instead of $2ndF$ $\pi$. 

14
<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 \( r \).

\[
r = 100 \left(\sqrt[3]{\frac{y}{a}} - 1\right)
\]

\[
r = 100 \left(\sqrt[3]{\frac{339422}{300000}} - 1\right)
\]

**Operation**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{ON/C} ) 400000 ( 1 + )</td>
<td></td>
</tr>
<tr>
<td>( \text{a/b} ) 5 100 ( )</td>
<td></td>
</tr>
<tr>
<td>) ( y^x ) 3 =</td>
<td>463'050,</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{ON/C} ) 100 ( 2ndF ( x\sqrt[3] ) )</td>
<td></td>
</tr>
<tr>
<td>5 100 ( a/b 339422 )</td>
<td></td>
</tr>
<tr>
<td>300000 ( ) =</td>
<td>2.499971984</td>
</tr>
</tbody>
</table>

15
The musical note A is 440 Hz.
Calculate the frequencies of the notes in (1) to (3).

(1) "C" of A, A# (B♭), B, C
400 \times \left(\frac{12}{\sqrt{2}}\right)^3

(2) "C" of A, G, F, E, D, C
400 \times \frac{\left(\frac{12}{\sqrt{2}}\right)^3}{2}

(3) "A" one octave higher
400 \times \left(\frac{12}{\sqrt{2}}\right)^{12}

---

### Example 3

(1)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/C 440</td>
<td>$440 \times \left(\frac{12}{\sqrt{2}}\right)^3$</td>
</tr>
<tr>
<td>2ndF $\sqrt[4]{\phantom{0}}$ 12</td>
<td>$523.2511306$</td>
</tr>
<tr>
<td>) $\sqrt[3]{\phantom{0}}$</td>
<td></td>
</tr>
<tr>
<td>$\sqrt[3]{\phantom{0}}$ 3</td>
<td></td>
</tr>
</tbody>
</table>

(2)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/C a/b 440</td>
<td>$440 \times \frac{\left(\frac{12}{\sqrt{2}}\right)^3}{2}$</td>
</tr>
<tr>
<td>( 2ndF $\sqrt[4]{\phantom{0}}$ 12</td>
<td>$261.6255653$</td>
</tr>
<tr>
<td>) 2</td>
<td></td>
</tr>
<tr>
<td>$\sqrt[3]{\phantom{0}}$ 3</td>
<td></td>
</tr>
<tr>
<td>$\sqrt[3]{\phantom{0}}$ 2</td>
<td></td>
</tr>
</tbody>
</table>

(3)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/C 440</td>
<td>$440 \times \left(\frac{12}{\sqrt{2}}\right)^{12}$</td>
</tr>
<tr>
<td>2ndF $\sqrt[4]{\phantom{0}}$ 12</td>
<td>$880.$</td>
</tr>
<tr>
<td>) $\sqrt[3]{\phantom{0}}$</td>
<td></td>
</tr>
<tr>
<td>$\sqrt[3]{\phantom{0}}$ 12</td>
<td></td>
</tr>
</tbody>
</table>
10 to the Power of x, Common Logarithm, Logarithm of x to Base a

\(10^x\)  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>

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>(2ndF) (10^x) 3  (=)</td>
<td>![Display Image 1]</td>
</tr>
<tr>
<td>(\log) 1000  (=)</td>
<td>![Display Image 2]</td>
</tr>
<tr>
<td>(2ndF) (\log_a x) 3  (=)</td>
<td>![Display Image 3]</td>
</tr>
</tbody>
</table>
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 \( M \).

### Example 1

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

\[
\begin{align*}
\text{ON/C} & \quad \text{2ndF} & \quad 10^x & \quad 1.5 \\
\times & \quad 1 & = & \quad 31.6227766
\end{align*}
\]

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

\[
\begin{align*}
\text{ON/C} & \quad \text{2ndF} & \quad 10^x & \quad 1.5 \\
\times & \quad 2 & = & \quad 1.35
\end{align*}
\]

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,

\[
\begin{align*}
\text{ON/C} & \quad \text{a/b} & \quad \log & \quad ( & \quad 8 \\
\times & \quad 2ndF & \quad 10^x & \quad 13 \\
\text{)} & \quad \text{)} & \quad \text{= } & \quad 4.8 \\
1.5 & \quad \text{= } & \quad 6.068726658
\end{align*}
\]
<Example 2> Air is held inside a cylinder of volume \( V_1 = 0.01 \text{ m}^3 \) at a pressure \( P_1 = 1,000,000 \text{ Pa} \) 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 \( P_2 = 101,000 \text{ Pa} \).

\[
Q = p_1V_1\ln\frac{p_1}{p_2} \\
\approx \frac{p_1V_1}{0.434}\log\frac{p_1}{p_2}
\]

### Operation

<table>
<thead>
<tr>
<th>ON/C</th>
<th>1000000</th>
<th>×</th>
<th>0.01</th>
<th>ln</th>
<th>[Display]</th>
</tr>
</thead>
<tbody>
<tr>
<td>a/b</td>
<td>1000000</td>
<td>→</td>
<td>101000</td>
<td>=</td>
<td>22.92634762</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ON/C</th>
<th>a/b</th>
<th>1000000</th>
<th>×</th>
<th>0.01</th>
<th>0.434</th>
<th>log</th>
<th>[Display]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>→</td>
<td>1000000</td>
<td>→</td>
<td>101000</td>
<td>=</td>
<td></td>
<td>22.94190383</td>
</tr>
</tbody>
</table>
<Example 3> Find the pH of hydrochloric acid HCl at a concentration of 1.0 x 10^{-8} mol/L

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

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

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

Enter the value of \(a\)

\[
\begin{array}{c}
\text{ON/C} \\
1.0 \\
\times \\
2\text{nd F} \\
10\text{x} \\
(\text{NEG}) \\
8 \\
\text{STO} \\
A
\end{array}
\]

Calculate the pH

\[
\begin{array}{c}
(\text{NEG}) \\
2\text{nd F} \\
\log_{10} \\
10 \\
\text{ALPHA} \\
A \\
+ \\
\sqrt{} \\
\text{ALPHA} \\
A \\
\times \\
2\text{nd F} \\
10\text{x} \\
(\text{NEG}) \\
\times \\
\text{ALPHA} \\
A \\
- \\
2 \\
= \\
\end{array}
\]

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

Use \(\sqrt{}\) instead of \(2\text{nd F} \sqrt{}\).
e to the Power of x, Natural Logarithm

\( e^x \) 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>

\[
\begin{array}{c|c|c}
\text{Operation} & \text{Display} \\
\hline
2\text{ndF} \quad e^x \quad 5 \quad \Rightarrow & e^5 = \\
& 148.4131591 \\
\hline
\ln \quad 10 \quad \Rightarrow & \ln 10 = \\
& 2.302585093 \\
\end{array}
\]
Factorials \( n! \)

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**

\[
7 \ 2\text{nd}F \ n! \ =
\]

**Display**

\[
7! = 5040
\]

c.f

\( n! = 1 \times 2 \times 3 \times \ldots \times n \)

**APPLICATIONS:**

Used in statistics and mathematics. In statistics, this function is used in calculations involving combinations and permutations.
Factorials \( n! \)

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

\[
3! = 3 \times 2 \times 1 = 6
\]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ON/C] 3 [2ndF] (n!)</td>
<td>[3! = 6]</td>
</tr>
</tbody>
</table>
<Example 1>
(1) When three cards are selected from five cards numbered 1 to 5 and placed in a row, how many possible orderings of the cards are there?

\[ _5P_3 = 5 \times 4 \times 3 \]

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

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

\[ C \times 3! = _5P_3 \]

Therefore \( C \) is

\[ C = _5P_3 \div 3! \]

*This is written as \(_5C_3\).*

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
</table>
| ON/C 5 2ndF nPr | \[ _5P_3 = \]
| 3 \[ = \] | 60. |

| ON/C 5 2ndF nPr | \[ _5P_3 \div 3! = \]
| 3 \[ ÷ \] 3 2ndF n! | 10. |

| ON/C 5 2ndF nCr | \[ _5C_3 = \]
| 3 \[ = \] | 10. |
<Example 2> Find the probability of drawing one pair when 5 cards are drawn from a deck of 52 cards. No jokers are included in the deck.

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

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

Ways of selecting two cards to make a pair
Ways of selecting the number: 13 possibilities from 1 to 13 (King)
Ways of selecting the suit: Two suits selected from four, \( \binom{4}{2} \)
Hence \( 13 \times \binom{4}{2} \)

Ways of selecting remaining three cards
Ways of selecting the number: Three types are selected from \((13 - 1)\) types \(\binom{12}{3}\)
Ways of selecting the suit: For each number on the three cards, there are 4 types of suit \(4^3\)
Hence \(\binom{12}{3} \times 4^3\)

Ways of selecting five cards
\(\binom{52}{5}\)
The probability of drawing one pair is
\((13 \times \binom{4}{2}) \times (\binom{12}{3} \times 4^3) ÷ \binom{52}{5}\)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/C</td>
<td></td>
</tr>
<tr>
<td>2ndF</td>
<td>(\binom{13}{2})</td>
</tr>
<tr>
<td>(\times)</td>
<td>12 2ndF</td>
</tr>
<tr>
<td>(\binom{3}{4})</td>
<td></td>
</tr>
<tr>
<td>2ndF</td>
<td>(\left(\frac{12 \times 4^3}{\binom{52}{5}}\right))</td>
</tr>
<tr>
<td>(\binom{52}{5})</td>
<td></td>
</tr>
</tbody>
</table>
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 \( \binom{3}{2} \).

\(<Example>\)

\begin{center}

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Operation} & 6 \text{ \textbf{2ndF} } nPr 4 \text{ } \text{=} & \text{Display} & 6 \text{C}4 = \\
\hline
\end{tabular}

\text{Display}: \text{N1} 360.

\begin{tabular}{|c|c|c|c|}
\hline
\textbf{Operation} & 6 \text{ \textbf{2ndF} } nCr 4 \text{ } \text{=} & \text{Display} & 6 \text{C}4 = \\
\hline
\end{tabular}

\text{Display}: \text{N1} 15.

\end{center}

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

In a certain year (year 0), the share of manufacturer A is 10% and the share of manufacturer B is 90%. Manufacturer A then releases a new product, and each following year it maintains 90% of the share $a_k$ it had the previous year (year $k$), and usurps 20% of the share $b_k$ of manufacturer B.

Find the transition matrix for this process and the shares of manufacturers A and B after 5 years.

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

\[
a_2 = 0.9a_1 + 0.2b_1 \\
b_2 = 0.1a_1 + 0.8b_1
\]

The transition matrix is

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

In the same way, after two years

\[
a_2 = 0.9a_1 + 0.2b_1 \\
b_2 = 0.1a_1 + 0.8b_1
\]

Expressing $a_2$ and $b_2$ using $a_0$ and $b_0$ gives

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

In summary,

\[
a_2 = 0.83a_0 + 0.34b_0 \\
b_2 = 0.17a_0 + 0.66b_0
\]

\[
A^2 = \begin{bmatrix} 0.83 & 0.34 \\ 0.17 & 0.66 \end{bmatrix} : \text{This is equal to mat}A^2. \text{(Refer to Example 1)}
\]
Finding $a_3$ and $b_3$ in the same way,

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

Expressing the coefficients as a matrix gives

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

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

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

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

- $a_2 = 0.72269a_0 + 0.55462b_0 = 57 \%$
- $b_2 = 0.27731a_0 + 0.44538b_0 = 43 \% \ (\text{Refer to Example 2 - 2})$
<Example 1>
Let
\[
\begin{bmatrix}
0.9 & 0.2 \\
0.1 & 0.8 \\
\end{bmatrix}
\]

Find matA^2 and matA^3

Set the mode to Matrix

\( \text{MODE} \ 4 \ (\text{MATRIX}) \)  Matrix mode

Enter matA

\( \text{MATH} \ 2 \ (\text{EDIT}) \)

\(<2 \times 2 \text{ Matrix}>\)

0.9  \( \text{ENTER} \)  0.2  \( \text{ENTER} \)

0.1  \( \text{ENTER} \)  0.8  \( \text{ENTER} \)

<Enter numeric values>

\( \text{ON/C} \ \text{MATH} \ 4 \ (\text{STORE}) \ 0 \)

<0: Save to matA>

Calculate

\( \text{ON/C} \ \text{MATH} \ 1 \ (\text{MATRIX}) \ 0 \)

\(<\text{Calculate the square}>\)

\( \text{ON/C} \ \text{MATH} \ 1 \ (\text{MATRIX}) \ 0 \)

\(<\text{Calculate the cube}>\)
Matrix Calculation

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

<Example 2>
Let

\[ \text{matB} = \begin{bmatrix} 0.83 & 0.34 \\ 0.17 & 0.66 \end{bmatrix} \quad \text{matC} = \begin{bmatrix} 0.781 & 0.438 \\ 0.219 & 0.562 \end{bmatrix} \]

(1) Find matB \times matC.

(2) The calculation result of (1) is

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

Letting \( a_0 = 10 \), \( b_0 = 90 \),
Calculate
\[
a_5 = ca_0 + db_0 \\
b_5 = ea_0 + fb_0
\]

**Operation**

Set the mode to Matrix

[MODE] 4 (MATRIX) Matrix mode

Enter matB

[MATH] 2 (EDIT)

2 2 \( \text{ENTER} \)

\(<2 \times 2 \text{ Matrix}>\)

0.83 \( \text{ENTER} \) 0.34 \( \text{ENTER} \)

0.17 \( \text{ENTER} \) 0.66 \( \text{ENTER} \)

\(<\text{Enter numeric values}>\)

[ON/C] [MATH] 4 (STORE) 1

\(<1: \text{Save to matB}>\)
Matrix Calculation

Enter matC

2 (EDIT)

Enter matC

<2 x 2 Matrix>

0.781 ENTER 0.438 ENTER

0.219 ENTER 0.562 ENTER

<Enter numeric values>

4 (STORE) 2

<2: Save to matC>

3. Calculate

(1)

1 (MATRIX)

1 (MATRIX) 2

(2)

ON/C

0.77269 × 10 +

0.55462 × 90 =

57.6427

0.27731 × 10 +

0.44538 × 90 =

42.8573
Time Calculation

Converting a sexagesimal value displayed in degrees, minutes, seconds to decimal notation. Also, converts a decimal value to sexagesimal notation (degrees, minutes, seconds).

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**

<table>
<thead>
<tr>
<th>24</th>
<th>D&gt;M’S</th>
<th>28</th>
<th>D&gt;M’S</th>
<th>35</th>
<th>2nd F</th>
<th>DEG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Convert to decimal notation</td>
<td></td>
</tr>
</tbody>
</table>

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 \( \frac{a}{b} \) \( ab\% \)

\( \frac{a}{b} \) Inputs proper or improper fractions which consist of a numerator and denominator.

\( ab\% \) Inputs a mixed fraction.

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 ( \text{2ndF} ) ( ab% ) 1 ( \gg ) 2 ( \gg ) + 5 ( \frac{a}{b} ) 7 ( \gg )</td>
<td><img src="image1" alt="Display1" /></td>
</tr>
<tr>
<td><img src="image2" alt="Change" /></td>
<td><img src="image3" alt="Display2" /></td>
</tr>
<tr>
<td><img src="image4" alt="Change" /></td>
<td><img src="image5" alt="Display3" /></td>
</tr>
<tr>
<td><img src="image6" alt="Change" /></td>
<td><img src="image7" alt="Display4" /></td>
</tr>
</tbody>
</table>

Convert to an improper fraction

Convert to decimal notation

**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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO 0 M</td>
<td>0:M</td>
</tr>
<tr>
<td>25 × 27 M+</td>
<td>25×27M+</td>
</tr>
<tr>
<td>7 × 3 M+</td>
<td>7×3M+</td>
</tr>
<tr>
<td>RCL M</td>
<td>M=</td>
</tr>
</tbody>
</table>

<Example 1>
- Stores displayed values in memory.
- Recalls values stored in memory.
- Adds the displayed value to the value in the independent memory.
- Subtracts the displayed value from the value in the independent memory.

A ~ F X Y memory registers
M independent memory

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>110 STO Y</td>
<td>110¥Y</td>
</tr>
<tr>
<td>26510 ÷ RCL Y =</td>
<td>26510÷Y=</td>
</tr>
<tr>
<td>2750 × RCL Y =</td>
<td>2750×Y=</td>
</tr>
</tbody>
</table>
**Last Answer Memory**  
\( \text{ANS} \)

**ANS**  
Automatically recalls the last answer calculated by pressing \( \equiv \)

**Example**  
Solve for \( x \) first and then solve for \( y \) using \( x \).

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

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>2ndF ( \sqrt{\phantom{0}} ) 2 + 3 =</td>
<td><img src="image1" alt="Display 1" /></td>
</tr>
<tr>
<td>4 ÷ ALPHA ANS =</td>
<td><img src="image2" alt="Display 2" /></td>
</tr>
<tr>
<td></td>
<td><img src="image3" alt="Display 3" /></td>
</tr>
</tbody>
</table>

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

Use \( \sqrt{\phantom{0}} \) instead of 2ndF \( \sqrt{\phantom{0}} \).
User-Defined Functions  

Recall a function that was defined by the user.

**<Example>**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>STO D1</td>
<td><img src="image" alt="STORING D1" /></td>
</tr>
<tr>
<td>2ndF hyp sin⁻¹</td>
<td><img src="image" alt="NORMAL MODE" /></td>
</tr>
<tr>
<td>D1 26 =</td>
<td><img src="image" alt="sin⁻¹26=" /></td>
</tr>
</tbody>
</table>

**APPLICATIONS:**

Functions that you have previously defined, including those using common 2nd Function buttons, can be stored in D1~D4 for later use, thus saving time on keystrokes.
**Absolute Value** \( \text{abs} \)

\( \text{abs} \)  Returns an absolute value.

<Example>

**Operation**

\[
\begin{align*}
\text{2nd} & \quad \text{abs} & \quad 3 & \quad \times \\
-4 & \quad ( & \quad 4 & \quad ) & \quad = \\
\end{align*}
\]

**Display**

\[
\begin{array}{c}
\text{\text{Abs}} \\
\text{W-MEM}
\end{array}
\quad \left| 3 \times -4 \right| = \\
\text{M} & \quad 12.
\]
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 1 meter from a building to the highest floor of the building is 45°. How tall is the building?

[DEG mode]

**Operation**
- \( \tan 45 \times 15 \)
- \( + 1 \circ 5 \)

**Display**

```
\[
tan45\times15+1.5=
\]
```

```
16.5
```

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.
<Example 2>

Find the length of the side of the following triangle.

\[ a = 20 \sin 30 \]
\[ b = 20 \cos 30 \]
\[ x = \frac{2}{\tan 17} \]
\[ y = \frac{2}{\sin 17} \]

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

[DEG mode]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ 2ndF \ SET\ UP ] 0 (DRG)</td>
<td></td>
</tr>
<tr>
<td>0 (DEG)</td>
<td></td>
</tr>
</tbody>
</table>

<Angle setting "s" (DEG)>
Trigonometric Functions \( \sin \cos \tan \)

\[
\text{ON/C} \\
20 \quad \sin \quad 30 \quad = \\
\text{ON/C} \\
20 \quad \cos \quad 30 \quad = \\
\text{a/b} \quad 2 \quad \rightarrow \quad \tan \\
17 \quad = \\
\text{a/b} \quad 2 \quad \rightarrow \quad \sin \\
17 \quad =
\]

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

Use \( \text{SET UP} \) instead of \( \text{2nd F SET UP} \).
<Example 3>
The instantaneous value \( V \) of the AC voltage is expressed by the equation below.

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

Root mean square value \( V_o = 100 \ [V] \)
Frequency \( f = 60 \ [\text{Hz}] \)

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

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

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2ndF</strong></td>
<td><strong>SET UP</strong></td>
</tr>
<tr>
<td><strong>1 (RAD)</strong></td>
<td></td>
</tr>
</tbody>
</table>

<Angle setting "rad" (RAD)>

\[
\begin{align*}
\sqrt{2} \times 100 \sin(2\pi \times 60 \times 2.000) &\approx 96.80958013 \\
\end{align*}
\]

\[
\begin{align*}
\sqrt{2} \times 100 \sin(2\pi \times 60 \times 2.002) &\approx 96.80958013 \\
\end{align*}
\]
Trigonometric Functions

Use \( \sqrt{ } \) instead of \( 2nd \ F \) \( \sqrt{ } \).

Use \( \sin \) instead of \( 2nd \ F \) \( \sin \).

Use \( \pi \) instead of \( 2nd \ F \) \( \pi \).

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

\[ \sqrt{2\times100\sin(2\times\pi\times60)} \]

\[ 141.1422935 \]

\[ \sqrt{2\times100\sin(2\times\pi\times60)} \]

\[ 17.72479587 \]

\[ \sqrt{2\times100\sin(2\times\pi\times60)} \]

\[ -138.9163952 \]

\[ \sqrt{2\times100\sin(2\times\pi\times60)} \]

\[ -35.17006112 \]
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.

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

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

<Example 1>
At what angle should an airplane climb in order to climb $80$ meters in $100$ meters?

[DEG mode]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2\text{ndF} \tan^{-1} (80 ÷ 100)$</td>
<td>$38.65900825$</td>
</tr>
</tbody>
</table>
The length $L$ of rope that creates this sag is expressed by the following equation.

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

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.
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:

$$v = Atanh(Bt) \text{ [m/s]}$$

$A = 6.82$

$B = 1.44$

($A$ 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)

$$\int_{0}^{15} (6.82 \text{tanh}(1.44x)) \, dx = 99.01718518$$

<table>
<thead>
<tr>
<th>$x$</th>
<th>$v$</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>6.0950185</td>
</tr>
<tr>
<td>2</td>
<td>6.777153851</td>
</tr>
<tr>
<td>5</td>
<td>6.819992397</td>
</tr>
<tr>
<td>10</td>
<td>6.82</td>
</tr>
<tr>
<td>15</td>
<td>6.82</td>
</tr>
</tbody>
</table>

Additional note: Simulation calculation

This function is convenient for repeated calculations using varying values of $X$.

1. Enter $\text{Atanh}(BX)$ (use the characters $A$, $B$, and $X$ to enter)

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

**MATH** 1 (ALGB)

*<Simulation calculation>*

3. Enter the value of $A$

$6.82$  $=$

*(If 6.82 appears, press only the $=$ key)*

4. Enter the value of $B$

$1.44$  $=$

*(If 1.44 appears, press only the $=$ key)*

5. Enter the value of $X$

For example,

$1$  $=$

6. The answer is obtained.

Repeat 2 to 6

$6.0950185$
The hyperbolic function is defined by using natural exponents in trigonometric functions.

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

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

→ rθ

Converts rectangular coordinates to polar coordinates (x, y → r, θ)

→ xy

Converts polar coordinates to rectangular coordinates (r, θ → x, y)

Splits data used for dual-variable data input.

<Example>

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

[DEG mode]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 (x, y) 3 2nd F → rθ</td>
<td>![Display Image]</td>
</tr>
<tr>
<td>7.6 (x, y) 23.2 2nd F → xy</td>
<td>![Display Image]</td>
</tr>
</tbody>
</table>

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)

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

- **→BIN** Converts to the binary system. **□□IN□** appears.
- **→PEN** Converts to the pental system. **□□EN□** appears.
- **→OCT** Converts to the octal system. **□OCT□** appears.
- **→HEX** Converts to the hexadecimal system. **□□EX□** appears.
- **→DEC** Converts to the decimal system. **□□IN□, □□EN□, □OCT□, and □□EX□ disappear from the display.

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

**<Example 1>**

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>2ndF →HEX 1AC</td>
<td>DEC 1AC... W-VIEW</td>
</tr>
<tr>
<td>2ndF →BIN</td>
<td>DEC 1AC+BIN W-VIEW</td>
</tr>
<tr>
<td>2ndF →PEN</td>
<td>DEC ANS+PEN W-VIEW</td>
</tr>
<tr>
<td>2ndF →OCT</td>
<td>DEC ANS+OCT W-VIEW</td>
</tr>
<tr>
<td>2ndF →DEC</td>
<td>DEC ANS+DEC W-VIEW</td>
</tr>
</tbody>
</table>

**<Example 2>**

1011 AND 101 = (BIN) →DEC

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>ON/C 2ndF →BIN 1011 AND 101</td>
<td>DEC 1011AND101= W-VIEW</td>
</tr>
<tr>
<td>2ndF →DEC</td>
<td>DEC ANS+DEC W-VIEW</td>
</tr>
</tbody>
</table>
<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.

\[
\text{Price elasticity of demand} = - \frac{\text{Rate of demand change}}{\text{Rate of price change}} = - \frac{dD}{dP} = - \frac{P \cdot dD}{dP}
\]

Find the following value when \( P=360 \) and \( D=48 \).

\[
- \frac{P}{D} \left[ \frac{d}{dx} \left( \frac{25920}{x} - 24 \right) \right]_{x=360}
\]

Operation  

\[ \text{ON/C} \quad \text{(−)} \quad \text{a/b} \quad 360 \]

\[ \text{48} \quad \text{2ndF} \]

\[ \frac{d}{dx} \quad \text{a/b} \quad 25920 \]

\[ \text{ALPHA} \quad \text{X} \quad \text{−} \]

\[ 24 \quad \text{360} \quad \text{=} \]

Display  

\[ \text{Function for EL-W506X/EL-W516X/EL-W506} \]

\[ 360 \quad \text{df} \quad \frac{25920}{x} - 24 \]

\[ x = 360 \]

\[ -48 \quad \text{360} \quad \text{=} \]

\[ 1.500000002 \]
<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**

1. \( \text{ON/C} \)
2. \( \text{2ndF} \)
3. \( d/dx \)
4. \( \text{2ndF} \)
5. \( \sqrt{ } \)
6. \( 1 \)
7. \( - \)
8. \( \text{ALPHA} \)
9. \( x \)
10. \( x^2 \)
11. \( \text{NEG} \)
12. \( \text{a/b} \)
13. \( 1 \)
14. \( = \)
15. \( 2 \)

**Display**

\[ \frac{d(\sqrt{1 - x^2})}{dx} \bigg|_{x = -\frac{1}{2}} = \frac{1}{\sqrt{3}} \approx 0.577350268 \]
Integration calculation \( \int dx \)

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

**Example 1**

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

1. Find the consumer surplus of the overall market.
   \[ \int_{0}^{100} (3000 - 10x - 2000) \, dx \]

2. Find the producer surplus of the overall market.
   \[ \int_{0}^{100} (2000 - 20x) \, dx \]

3. Find the total surplus of the overall market.
   \[ \int_{0}^{100} (3000 - 10x - 20x) \, dx \]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{ON/C} ) ( \int dx ) 0 ( \rightarrow )</td>
<td>![Display 1]</td>
</tr>
<tr>
<td>100 ( \rightarrow ) (3000)</td>
<td>![Display 2]</td>
</tr>
<tr>
<td>(-) 10 ( \text{ALPHA} ) ( x )</td>
<td>![Display 3]</td>
</tr>
<tr>
<td>(-) 2000 ( ) ( \equiv )</td>
<td>![Display 4]</td>
</tr>
</tbody>
</table>

(2)

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \text{ON/C} ) ( \int dx ) 0 ( \rightarrow )</td>
<td>![Display 5]</td>
</tr>
<tr>
<td>100 ( \rightarrow ) (2000)</td>
<td>![Display 6]</td>
</tr>
<tr>
<td>(-) 20 ( \text{ALPHA} ) ( x )</td>
<td>![Display 7]</td>
</tr>
<tr>
<td>( ) ( \equiv )</td>
<td>![Display 8]</td>
</tr>
</tbody>
</table>
Integration calculation

\[ \int dx \]

(3)

\[ \text{ON/C} \quad \int dx \quad 0 \quad \rightarrow \]

100 \quad \rightarrow \quad ( \quad 3000 \quad )

- 10 \quad \text{ALPHA} \quad x

- 20 \quad \text{ALPHA} \quad x

) \quad =

\[ \int_{100}^{20} (3000 - 10x - 20x) \, dx \]

\[ = \int_{100}^{20} (3000 - 30x) \, dx \]

\[ = \left[ 3000x - 1500x^2 \right]_{100}^{20} \]

\[ = (3000(20) - 1500(20)^2) - (3000(100) - 1500(100)^2) \]

\[ = 60000 - 6000000 - (3000000 - 15000000) \]

\[ = 1500000 \]
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°.
\[ \int_{0}^{1} \sqrt{1 - x^2} \, dx \]
<Example 1>
Let the hydrochloric acid concentration be \( c = 1.0 \times 10^{-8} \text{ mol / l} \), 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
\[
K_w = 1.0 \times 10^{-14} \text{ [mol / l]} \] (ionic product of water)

(2) Use the result of (1) to find the pH (= - \log x) of hydrochloric acid.
\[
pH = - \log x \quad (x>0)
\]

### Operation & Display

(1)

Save constants

- **MODE**: 0 (NORMAL)
- **ON/C**
- **1.0**
- **Exp**
- **(−)**
- **14**
- **STO**
- **B**
- **1.0**
- **Exp**
- **(−)**
- **8**
- **STO**
- **C**
- **Display**: 1.0E-8 + C
- **Display**: 0.00000001
Set the mode to Equation

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

<QQuadratic equation>

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

1

(−) ALPHA C

(−) ALPHA B

(2)

Set the mode to Normal

**MODE** 0 (NORMAL)

ON/C (−) log

0.000000105 =

-\log 0.000000105 =

6.978810781
Let the acetic acid concentration be \( c (= 0.1 \text{ mol} / \ell) \), 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

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

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

\[ \text{pH} = - \log x \ (x>0) \]

(1)

Save constants

<table>
<thead>
<tr>
<th>Operation</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>( 0 ) (NORMAL)</td>
<td>( 2.75 ) ( \exp ) (-) ( 5 )</td>
</tr>
<tr>
<td>( \text{STO} )</td>
<td>( A )</td>
</tr>
<tr>
<td>( 0.1 ) ( \text{STO} )</td>
<td>( 1 ) ( \frac{1}{10} )</td>
</tr>
</tbody>
</table>

Polynomial equation

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

Set the mode to Equation

MODE 6 (EQUATION)
3 (CUBIC)

<Cubic equation>

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

1 \( \text{ENTER} \)

\( \text{ALPHA} \text{ A } \text{ENTER} \)

\( \text{NEG} \) \( \text{ALPHA} \text{ C } \)

\( \text{ALPHA} \text{ A } + \text{ALPHA} \text{ B } \text{ENTER} \)

(2)

Set the mode to Normal

MODE 0 (NORMAL)

ON/C \( \text{NEG} \) log

0.001644619 \( \text{ENTER} \)
<Example 1>
To produce one unit of product $X$, 3 kg of material $A$ and 1 kg of material $B$ are required.
To product one unit of product $Y$, 1 kg of material $A$ and 2 kg of material $B$ are required.
There are 9 kg of $A$ and 8 kg of $B$ in stock.
If the selling price of product $X$ is 30,000 yen/unit and the selling price of product $Y$ is 20,000 yen/unit, how many units of product $X$ and how many units of product $Y$ should be produced in order to maximize sales $K$?
(Do not include the cost of materials and production or other expenses)

If the quantities produced of each product are $x$ and $y$, the sales $K$ can be expressed as
$$K = 3x + 2y$$
The following relations hold for the quantities in stock:
$$3x + y \leq 9$$
$$x + 2y \leq 8$$
$$x \geq 0, \ y \geq 0$$
Based on these conditions, find the values of $x$ and $y$ that maximize sales $K$.

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

The intersection point $P$ can be obtained from the following simultaneous equations:
$$3x + y = 9$$
$$x + 2y = 8$$
Solving these gives
$$x = 2, \ y = 3$$
and thus the maximum value of the sales $K$ is
$$K = 3 \times 2 + 2 \times 3 = 12 \times 10,000$$ yen (when $x = 2$ units and $y = 3$ units)
(1) Solve the following simultaneous equations.
\[3x + y = 9\]
\[x + 2y = 8\]

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

---

**Operation**

Set the mode to Equation

**Display**

- **MODE 6 (EQUATION)**
  - **Set the mode to Equation**
  - **<Equation mode>**
  - **0 (2-VLE)**
    - **<Simultaneous linear equations in two unknowns>**
    - **Enter the coefficients**
      - \(a_1 = 3, b_1 = 1, c_1 = 9\)
      - \(a_2 = 1, b_2 = 2, c_2 = 8\)

**Display**

- **3 ENTER 1 ENTER 9 ENTER**
- **1 ENTER 2 ENTER 8 ENTER**

---

**Operation**

Set the mode to Normal

**Display**

- **MODE 0 (NORMAL)**

**Display**

- **3 \times 2 +**
- **2 \times 3 =**

\[3 \times 2 + 2 \times 3 = 12\]
When ethanol \( \text{C}_2\text{H}_5\text{OH} \) is completely combusted, carbon dioxide \( \text{CO}_2 \) and water \( \text{H}_2\text{O} \) are created. The chemical reaction formula of this reaction is expressed as follows:

\[
x \ \text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow y \ \text{CO}_2 + z \ \text{H}_2\text{O}
\]

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

The numbers of C, H, and O before and after the reaction are equal, hence:
- Number of C: \( 2x = y \)
- Number of H: \( 5x + 1 = y \)
- Number of O: \( x + 3 \times 2 = z \)

As such, the following simultaneous equations are obtained:

\[
\begin{align*}
2x - y + & = 0 \\
6x - 2z & = 0 \\
x - 2y - z & = -6
\end{align*}
\]

Solving these gives

\[
x = 1, \ y = 2, \ z = 3
\]

and the chemical reaction formula is

\[
\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}
\]

---

**Operation**

Set the mode to Equation

\[\text{MODE} \quad 6 \ (\text{EQUATION})\]

\**Example 2***

When ethanol \( \text{C}_2\text{H}_5\text{OH} \) is completely combusted, carbon dioxide \( \text{CO}_2 \) and water \( \text{H}_2\text{O} \) are created. The chemical reaction formula of this reaction is expressed as follows:

\[
x \ \text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow y \ \text{CO}_2 + z \ \text{H}_2\text{O}
\]

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: \( 2x = y \)
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\end{align*}
\]

Solving these gives

\[
x = 1, \ y = 2, \ z = 3
\]

and the chemical reaction formula is

\[
\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}
\]

---

**Display**

Set the mode to Equation

\[\text{MODE} \quad 6 \ (\text{EQUATION})\]

\**Example 2***

When ethanol \( \text{C}_2\text{H}_5\text{OH} \) is completely combusted, carbon dioxide \( \text{CO}_2 \) and water \( \text{H}_2\text{O} \) are created. The chemical reaction formula of this reaction is expressed as follows:

\[
x \ \text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow y \ \text{CO}_2 + z \ \text{H}_2\text{O}
\]

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

The numbers of C, H, and O before and after the reaction are equal, hence:
- Number of C: \( 2x = y \)
- Number of H: \( 5x + 1 = y \)
- Number of O: \( x + 3 \times 2 = z \)

As such, the following simultaneous equations are obtained:

\[
\begin{align*}
2x - y + & = 0 \\
6x - 2z & = 0 \\
x - 2y - z & = -6
\end{align*}
\]

Solving these gives

\[
x = 1, \ y = 2, \ z = 3
\]

and the chemical reaction formula is

\[
\text{C}_2\text{H}_5\text{OH} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O}
\]
An AC sine wave voltage of 100 V, 50 Hz is applied to a circuit consisting of a resistor ($R = 250\Omega$) and capacitor ($C = 20 \times 10^{-6}\text{F}$) connected in parallel. Find the impedance of this circuit.

Circuit impedance = Value of polar coordinate $r$

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

### Operation

<table>
<thead>
<tr>
<th>MODE 3 (CPLX)</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complex mode</td>
<td><img src="image1" alt="Complex Mode Display" /></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2ndF $\rightarrow xy$</th>
<th>(Rectangular coordinates)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1 \div$</td>
<td>( ( ) )</td>
</tr>
<tr>
<td>$1 \div$</td>
<td>$250$ ( )</td>
</tr>
<tr>
<td>$+$</td>
<td>$2$ ( ) $\pi$</td>
</tr>
<tr>
<td>$\times$</td>
<td>$50 \times$</td>
</tr>
<tr>
<td>$\text{Exp}$ $\rightarrow$ $\text{xy}$</td>
<td>$6$ ( )</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2ndF SET UP 0 (DRG)</th>
<th>Display</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\text{MODE}$</td>
<td>$\text{DRG}$</td>
</tr>
<tr>
<td>$\theta$</td>
<td>$\text{DEG}$ $1$: $\text{RAD}$ $2$: $\text{GRAD}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1 (RAD)</th>
<th>(Angle units: RAD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$2ndF$ $\rightarrow r\theta$</td>
<td>(Polar coordinates)</td>
</tr>
</tbody>
</table>

**Example 1**

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

```
1 ÷ (1 ÷ 250) + 2π × 50
\[\times20\text{E}^{-6}\text{i}\] =
72.10010979
-113.25458761
```

```
0: $\text{DEG}$ 1: $\text{RAD}$ 2: $\text{GRAD}$
```

```
1 ÷ (1 ÷ 250) + 2π × 50
\[\times20\text{E}^{-6}\text{i}\] =
134.257318
-1.003684822
```
An AC sine wave voltage of 100V, 60Hz is applied to a circuit consisting of a resistor \( R = 120 \), coil \( L = 4 \) H, and capacitor \( C = 3 \times 10^{-6} \) F connected in series.

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

Circuit impedance = Value of polar coordinate \( r \)
Phase difference = Polar coordinate \( \theta \)

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

\[
Z = 120 + 2 \pi \times 60 \times 4 \times i + 1 + (2 \pi \times 60 \times 3 \times 10^{-6} \times i)
\]

\[
Z = 120 + 2 \pi \times 60 \times 4 \times i + 1 + (2 \pi \times 60 \times 3 \times 10^{-6} \times i) = 120 + 623.7703454 i
\]

Display

\[
2 \text{nd F} \quad \text{SET UP} \quad 0 \quad (\text{DRG})
\]

\[
0 \quad (\text{DEG}) \quad (\text{Angle units: DEG})
\]

\[
2 \text{nd F} \quad \rightarrow r \theta \quad (\text{Polar coordinates})
\]

\[
63
\]
The statistics function is excellent for analyzing qualities of an event. Though primarily used for engineering and mathematics, the function is also applied to nearly all other fields including economics and medicine.

**DATA INPUT AND CORRECTION**

- **DATA** Enters data for statistical calculations.
- **CD** Clears data input.
- **(x,y)** Splits data used for dual-variable data input.
  (Used for dual-variable statistical calculations.)

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

<table>
<thead>
<tr>
<th>Data table 1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>No.</strong></td>
</tr>
<tr>
<td><strong>Score</strong></td>
</tr>
<tr>
<td><strong>No. of pupils</strong></td>
</tr>
</tbody>
</table>

**Operation**

- **MODE 1 0** Select single-variable statistics mode

- **30 (x,y) 2 DATA**

- **100 (x,y) 2 DATA**
**“ANS” KEYS FOR 1-VARIABLE STATISTICS**

- \( \bar{x} \) Calculates the average value of the data (sample data x).
- \( s_x \) Calculates the standard deviation for the data (sample data x).
- \( \sigma_x \) Calculates the standard deviation of a data population (sample data x).
- \( n \) Displays the number of input data (sample data x).
- \( \Sigma x \) Calculates the sum of the data (sample data x).
- \( \Sigma x^2 \) Calculates the sum of the data (sample data x) raised to the second power.

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

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

<table>
<thead>
<tr>
<th>Key</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \bar{x} )</td>
<td>69</td>
<td>Average value</td>
</tr>
<tr>
<td>( s_x )</td>
<td>17.75686128</td>
<td>Standard deviation</td>
</tr>
<tr>
<td>( \sigma_x )</td>
<td>17.57839583</td>
<td>Standard deviation of the population</td>
</tr>
<tr>
<td>( n )</td>
<td>50</td>
<td>Total count of data</td>
</tr>
<tr>
<td>( \Sigma x )</td>
<td>3450</td>
<td>Total</td>
</tr>
</tbody>
</table>

Calculated values:
- \( \bar{x} \) = 69
- \( s_x \) = 17.75686128
- \( \sigma_x \) = 17.57839583
- \( n \) = 50
- \( \Sigma x \) = 3450
When the weight of a calculator was measured, the results at left were obtained. Find the average and standard deviation of the weight.

<table>
<thead>
<tr>
<th>No</th>
<th>Weight [g]</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>97.27</td>
</tr>
<tr>
<td>2</td>
<td>96.83</td>
</tr>
<tr>
<td>3</td>
<td>96.65</td>
</tr>
<tr>
<td>4</td>
<td>96.90</td>
</tr>
<tr>
<td>5</td>
<td>96.77</td>
</tr>
</tbody>
</table>

**Operation**

Select Statistics mode

2ndF CA

97.27 DATA

96.83 DATA

... DATA

96.77 DATA

Average

\[ \bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i \]

\[ \bar{x} = \frac{1}{5} (97.27 + 96.83 + 96.65 + 96.90 + 96.77) = 96.84 \]

Standard deviation

\[ \sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} (x_i - \bar{x})^2} \]

\[ \sigma = \sqrt{\frac{1}{4} ((97.27 - 96.84)^2 + (96.83 - 96.84)^2 + (96.65 - 96.84)^2 + (96.90 - 96.84)^2 + (96.77 - 96.84)^2)} = 0.209723627 \]
<Example 3>

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 $r$.

<table>
<thead>
<tr>
<th>Spring extension $x$ [m]</th>
<th>Force $F$ [N]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.028</td>
<td>0.2</td>
</tr>
<tr>
<td>0.073</td>
<td>0.39</td>
</tr>
<tr>
<td>0.118</td>
<td>0.6</td>
</tr>
<tr>
<td>0.16</td>
<td>0.77</td>
</tr>
<tr>
<td>0.207</td>
<td>1</td>
</tr>
</tbody>
</table>

Select Statistics mode

MODE 1 (STAT) 1 (LINE)

Select Statistics mode

2ndF CA

0.028 $(x,y)$ 0.20 DATA
0.073 $(x,y)$ 0.39 DATA
...
0.207 $(x,y)$ 1.00 DATA

Display

$a = 0.070355029$

$b = 4.450895652$

$r = 0.999620559$
<Example 4>

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

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

<table>
<thead>
<tr>
<th>Time x [S]</th>
<th>Thermometer temperature [°C]</th>
<th>Temperature difference [°C] from hot</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>25</td>
<td>67</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>55</td>
<td>37</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>71</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>79</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>85</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>88</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>90</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>90</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>32</td>
<td>91</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>36</td>
<td>91</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>91</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>67</td>
</tr>
<tr>
<td>4</td>
<td>37</td>
</tr>
<tr>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>12</td>
<td>13</td>
</tr>
<tr>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>32</td>
<td>1</td>
</tr>
<tr>
<td>36</td>
<td>1</td>
</tr>
<tr>
<td>40</td>
<td>1</td>
</tr>
</tbody>
</table>

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.

**Operation**

**Display**

**MODE** 1 (STAT) 3 (E_EXP)

Select Statistics mode

2ndF CA

0 (x, y) 67 DATA

4 (x, y) 37 DATA

... 

40 (x, y) 1 DATA

"DATA SET= 11."
2. (Cartesian coordinates)

Polar coordinates

\( \theta \) (DRG)

1 250

50 20

3. Standard deviation
DATA CORRECTION

Correction prior to pressing DATA immediately after a data entry: Delete incorrect data with COMP, then enter the correct data.

Correction after pressing DATA:

Use [ ▲ ▼ ] to display the data previously entered. Press [▼] to display data items in ascending (oldest first) order. To reverse the display order to descending (latest first), press the [▲] key. Each item is displayed with 'X:', 'Y:', or 'F:' (n is the sequential number of the data set).

Display the data item to modify, input the correct value, then press DATA. Using [▲ ▼], you can correct the values of the data set all at once.

• When ▲ or ▼ appears, more data items can be browsed by pressing ▲ or ▼.
• To delete a data set, display an item of the data set to delete, then press COMP. The data set will be deleted.
• To add a new data set, press COMP and input the values, then press DATA.

<Example 1>
Data table 2

<table>
<thead>
<tr>
<th>X: 30, 40, 40, 50</th>
</tr>
</thead>
<tbody>
<tr>
<td>X: 30, 45, 45, 45, 60</td>
</tr>
</tbody>
</table>

### Operation

#### MODE 1 0
Select single-variable statistics mode

#### 30 DATA

#### 40 \(x, y\) 2 DATA

#### 50 DATA

### Display

- **Stat 0 [SD]**
  - N: 0

- **50DATA**
  - DATA SET= 1.

- **40, 2DATA**
  - DATA SET= 2.

- **50DATA**
  - DATA SET= 3.
APPLICATIONS:
Single-variable statistical calculations are used in a broad range of fields, including engineering, business, and economics. They are most often applied to analysis in atmospheric observations and physics experiments, as well as for quality control in factories.
Example 2: The table below summarizes the dates in April when cherry blossoms bloom, and the average temperature for March in that same area. Determine basic statistical quantities for data X and data Y based on the data table.

Data table 3

<table>
<thead>
<tr>
<th>Year</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td>6.2</td>
<td>7.0</td>
<td>6.8</td>
<td>8.7</td>
<td>7.9</td>
<td>6.5</td>
<td>6.1</td>
<td>8.2</td>
</tr>
<tr>
<td>y</td>
<td>6.1</td>
<td>13</td>
<td>15</td>
<td>12</td>
<td>7</td>
<td>11</td>
<td>9</td>
<td>11</td>
</tr>
</tbody>
</table>

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

6.2 \((x, y)\) 13 DATA

6.1 \((x, y)\) 15 DATA

8.2 \((x, y)\) 7 DATA
“ANS” KEYS FOR 2-VARIABLE STATISTICS

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

- **Σxy**: Calculates the sum of the product for sample data x and sample data y.
- **Σy**: Calculates the sum of the data (sample data y).
- **Σy²**: Calculates the sum of the data (sample data y) raised to the second power.
- **y̅**: Calculates the average value of the data (sample data y).
- **sv**: Calculates the standard deviation for the data (sample data y).
- **σy**: Calculates the standard deviation of a data population (sample data y).

**NOTE:**

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

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

- **RCL Σx**: 7.175 (Average for data x)
- **RCL sx**: 0.973579551 (Standard deviation for data x)
- **RCL σx**: 0.91070028 (Standard deviation of the population for data x)
- **RCL y̅**: 9.875 (Average for data y)
- **RCL sy**: 3.440826313 (Standard deviation for data y)
- **RCL σy**: 3.218598297 (Standard deviation of the population for data y)
- **RCL n**: 8 (Total count of data)
- **RCL Σx**: 57.4 (Sum of data x)
- **RCL Σx²**: 418.48 (Sum of data x raised to the second power)
- **RCL Σxy**: 544.1 (Sum of the product of data x and data y)
- **RCL Σy**: 79 (Sum of data y)
- **RCL Σy²**: 863 (Sum of data y raised to the second power)