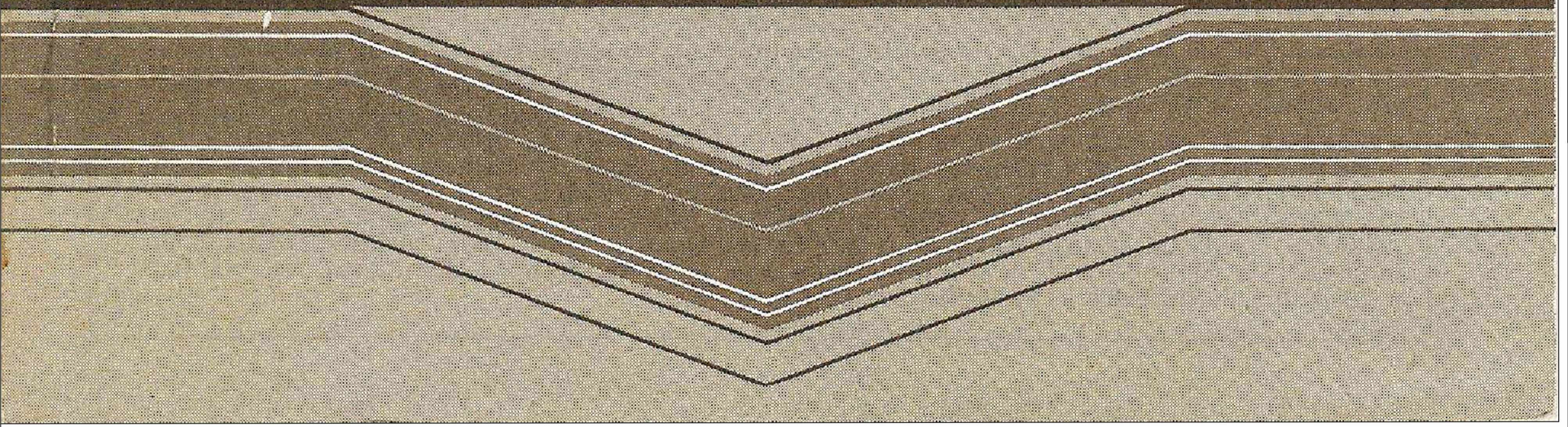
SHARP

SCIENTIFIC CALCULATOR

MODEL EL-512

INSTRUCTION MANUAL



(ELECTRONIC CALCULATOR)
LIMITED WARRANTY:

SHARP ELECTRONICS CORPORATION warrants this product to the original purchaser to be free from defective materials and workmanship. Under this warranty the product will be repaired or replaced, at our option, without charge for parts or labor, with the exception of batteries, when returned to a SHARP CONSUMER FACTORY SERVICE CENTER listed in the instruction booklet supplied with your unit.

This warranty does not apply to any appearance items nor to any product whose exterior has been damaged or defaced, nor to any product subjected to misuse, abnormal service or handling, nor to any products altered or repaired by other than a SHARP CONSUMER FACTORY SERVICE CENTER. This warranty does not apply to any product purchased outside the United States, its territories, or possessions.

The period of this warranty covers one (1) year on parts and one (1) year on labor from date of purchase.

This warranty entitles the original purchaser to have the warranted parts and labor rendered at no cost for the period of the warranty described above when the unit is carried or shipped, prepaid, to a SHARP CONSUMER FACTORY SERVICE CENTER together with proof of purchase.

THIS SHALL BE THE EXCLUSIVE WRITTEN WARRANTY OF THE ORIGINAL PURCHASER AND NEITHER THIS WARRANTY NOR ANY OTHER WARRANTY, EXPRESSED OR IMPLIED, SHALL EXTEND BEYOND THE PERIOD OF THE TIME LISTED ABOVE. IN NO EVENT SHALL SHARP BE LIABLE FOR CONSEQUENTIAL ECONOMIC DAMAGE OR CONSEQUENTIAL DAMAGE TO PROPERTY. SOME STATES DO NOT ALLOW A LIMITATION ON HOW LONG AN IMPLIED WARRANTY LASTS OR AN EXCLUSION OF CONSEQUENTIAL DAMAGE, SO THE ABOVE LIMITATION AND EXCLUSION MAY NOT APPLY TO YOU. IN ADDITION, THIS WARRANTY GIVES SPECIFIC LEGAL RIGHTS, AND YOU MAY HAVE OTHER RIGHTS WHICH VARY FROM STATE TO STATE.

CONTENTS

INTRODUCTION

Congratulation on your purchase of the SHARP scientific calculator, model EL-512.

This manual will introduce you to the Sharp EL-512 scientific calculator.
Some sections in this manual may be divided into basic and advanced material. The advanced material is labeled "supplementary." The supplementary sections may be skipped without hampering your ability to operate the calculator. You may wish to return to the supplementary sections as your skill in operating the EL-512 increases.

OPERATIONAL NOTES

Since the liquid crystal display is made of glass material, treat the calculator with care. Do not put your "EL-512" in your back pocket as it may be damaged when you sit down.

To insure trouble-free operation of your SHARP calculator, we recommend the following:

1. The calculator should be kept in areas free from extreme temperature changes, moisture and dust.
   During warm weather, vehicles left in direct sun light are subject to high temperature build up.
   Prolonged exposure to high temperature may cause damage to your calculator.
2. A soft, dry cloth should be used to clean the calculator. Do not use solvents or a wet cloth.
3. If the calculator will not be operated for an extended period of time, remove the batteries to avoid possible damage caused by battery leakage.
4. If service of your calculator is required, use only an authorized SHARP service center.
5. Keep this manual for further reference.

FEATURES

1) Direct Formula Entry

- Direct formula entry for entering formulas as they are written with no need for translation into machine language.

  Example $5 + 2 \times \sin 30 + 24 \times 5^3 =$

  Operation [5] [+] [2] [×] [3] [0] [sin] [+] [2] [4] [×] [5] [y^x] [3] [=]

- 15 levels of parentheses and 8 levels of pending operation.

2) Multi Formula Reserve

- Four kinds of formulas can be stored into the formula reserve memory by the LEARN mode.
  Maximum capacity of the memory is 128 steps.

3) Multiple Storage Memories

- Nine storage memories for storing constants and results.
- Independently accessible 3-key memory with [x→M] , [RM] and [M+] keys.

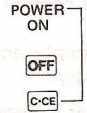
4) Hexadecimal ⟷ Decimal notation conversions

Hexadecimal notation system is mainly used in computer programming.
Computer engineers and programmers have been in urgent need for a simple conversion of decimal and hexadecimal notations.
Now, EL-512 has solved the problem. Simply enter a number in base 16 or 10, the EL-512 will then give you the answer instantly.

5) Double-variable statistical function and linear regression

NORMAL CALCULATIONS

TURNING THE POWER ON



To turn the power on press the red C·CE key. To turn the power off press the OFF key. Sharp calculator has the A.P.O. (Automatic Power OFF). If the calculator is turned on in error, or no calculation is performed, the calculator will turn itself off after about nine minutes, saving battery power. To turn the EL-512 back on press the C·CE key.
To floating decimal system, depress the 2ndF TAB F↔E and • keys.
(Details, see "Decimal Places")

CLEARING

C·CE , →

An incorrectly entered number can be replaced as long as the number has not already been followed by a "function key."

For example:

Key in: 5 × 4 (The 4 should be 6)

Key in: C·CE 6 =

Answer: 30

To clear the latest entry press the C·CE key once. If the C·CE key is pressed twice, the calculator will be completely cleared except for material in memory. All previous calculations will be cleared if the C·CE key is pressed after a function key.

In case of one digit correction of the entered number, use the right shift key.

Key in: 123 + 12345687 (The 87 should be 78)

Key in: → → 78 =

Answer: 12345801

BASIC FUNCTIONS AND THE EQUALS KEY

+ − × ÷ = Addition, Subtraction, Multiplication, Division, Equals

1. Addition, Subtraction

Key in: 123 [+] 456 [+] 789 [=] Answer: 1368

Key in: 100 [−] 25 [−] 35 [=] Answer: 40

Pressing the [=] key gives the answer to the entered formula.

Using a constant:

The calculator is equipped with a built-in constant feature which allows repetitive calculations (calculating with the same number without having to re-enter that number and the function key).

Key in: 10 [+] 20 [=] Answer: 30

20 is now a constant for further additions:

Key in: 60 [=] Answer: 80

> Some calculations require slightly longer time depending on the contents.
> If nothing appears on the display during calculation do not continue making entries.

To use the sum of numbers as a constant use [(] and [)] keys.

Key in: 10 [+] [(] 20 [+] 5 [)] [=] Answer: 35

Key in: 4 [=] Answer: 29

Key in: 100 [−] 25 [=] Answer: 75

Key in: 40 [=] Answer: 15

Key in: 50 [−] [(] 10 [−] 2 [)] [=] Answer: 42

Key in: 20 [=] Answer: 12

2. Multiplication, Division

Calculate: 50 x (−2) ÷ 4

Key in: 50 [×] 2 [+/−] [÷] 4 [=]

Note: To enter a negative number, press the [+/−] key after numerals.

Answer: −25

Calculate: 5 + 2 x 3 − 2 ÷ 0.5

Key in: 5 [+] 2 [×] 3 [−] 2 [÷] .5 [=]

Answer: 7 ↑—(Press [•])

Note that multiplication and division have priority to addition and subtraction. In other words multiplication and division will occur before addition and subtraction.

Constant Multiplication: The first number entered is the multiplicand.

Key in: 3 [×] 5 [=] Answer: 15

Key in: 10 [=] Answer: 30

Constant Division: The number entered after the division sign is the divisor.

Key in: 15 [÷] 3 [=] Answer: 5

Key in: 30 [=] Answer: 10

Note: The machine retains some calculations depending on priority level. Accordingly, in successive calculation the operator of the last calculation and the last numerical value are handled as a calculating instruction and a constant for constant calculation, respectively.

a + b x c =	+bc	(Constant addition)
a x b ÷ c =	÷ c	(Constant division)
a ÷ b x c =	$\frac{a}{b}$ x	(Constant multiplication)
a x b − c =	− c	(Constant subtraction)

3. Use of parenthesis

The parentheses keys are needed to cluster together a series of operations when it is necessary to override the priority system of algebra. When parentheses are in use on the EL-512 the symbol ( ) will appear in the display.

Calculations in parentheses have priority over other calculations. Parentheses can be used up to 15 times in a single level. Calculations within the inner-most set of parentheses will be calculated first.

Calculate: 12 + 42 ÷ (8 − 6)

Key in: 12 [+] 42 [÷] [(] 8 [−] 6 [)] [=]

Answer: 33

Calculate: 126 ÷ [(3 + 4) x (3 − 1)]

Key in: 126 [÷] [(] [(] 3 [+] 4 [)] [×] [(] 3 [−] 1 [)] [)] [=]

Answer: 9

can be omitted

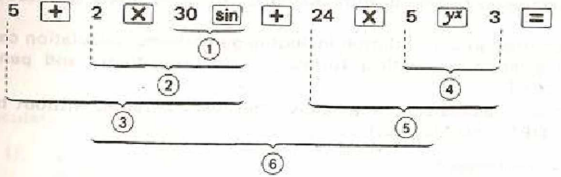
Note: The [)] keys located just before the [=] key can be omitted.

Supplementary 1 – priority level

The machine, provided with a function that judges the priority level of individual calculations, permits keys to be operated according to a given mathematical formula. The following shows the priority level of individual calculations.

Level	Operations
(1)	• Single-variable functions which are calculated as entered like sin, ln, 10^x, $1/x$, x^2. • Multiplication cleared of "x" instruction located just before storage memory or π. (such as 2π, $4K_1$)
(2)	Multiplication cleared of "x" instruction located just before the "(" (open parenthesis).
(3)	y^x, $\sqrt[x]{y}$
(4)	x, ÷ (Calculations which are given the same priority level are executed in sequence.)
(5)	+, –
(6)	=, M+

Ex. Key operation and sequence of calculation in $5 + 2 \times \sin 30 + 24 \times 5^3 =$



The numbers ① ~ ⑥ indicates the sequence in which the calculations are carried out.

When calculations are executed from higher priority one in sequence a lower priority one must be reserved. The machine is provided with memories of eight levels to meet such requirement.
As the memories can be also used in a calculation including parentheses, calculation can be performed according to a given mathematical formula unless parentheses and pending operation exceed 8 levels in total.

- Single-variable functions are calculated immediately after key operation without being retained. (x^2, $1/x$, n!, →DEG, →D·MS, etc.)

〈 Calculation without using parentheses 〉

Ex. a [+] b [=] — Pending of 1 level

a [+] b [×] c [=] — Pending of 2 levels

a [+] b [×] c [y^x] d [=] — Pending of 3 levels

a [+] b [×] c [y^x] d [÷] e

With the [y^x] pressed, 3 calculations remain pending. Pressing the [÷] key executes the calculations of "y^x" highest in priority level and "x" identical in priority level. After the [÷] key is pressed, the other 2 calculations will remain pending.

〈 Calculation using parentheses 〉

Ex. i) a [+] b [×] c [y^x] [(] d [÷] e

4 numerals and calculation instructions are left pending.

ii) a [+] b [×] [(] c [−] d [÷] e [)]

Pressing the [)] key executes the calculation of c − d ÷ e in the parentheses, leaving 2 calculations pending.

- Parentheses can be used unless pending calculations exceed 8. However, parentheses can be continuously used up to 15 times.
  Ex. Parentheses, if continued, can be used up to 15.
  a × (((b − c × (((d + e) × f) ÷ g ·····

- A multiplication with "x" immediately before "(" omitted becomes higher in priority level than y^x, $\sqrt[x]{y}$, x and ÷.
  Its calculation is performed first, differing from the calculation of a multiplication with "x" included.

Ex. 2 ÷ 5 (2 + 3) = → $\frac{2}{5 \times (2+3)} = \frac{2}{25} = 0.08$

2 ÷ 5 × (2 + 3) = → $\frac{2}{5} \times (2+3) = \frac{2}{5} \times 5 = 2$

2 ÷ 3 (2 + 3) y^x 2 = → $\frac{2}{(3 \times (2+3))^2} = \frac{2}{15^2} = 0.00888\cdots$

2 ÷ 3 × (2 + 3) y^x 2 = → $\frac{2}{3} \times (2+3)^2 = \frac{2}{3} \times 5^2 = 16.666$

2 y^x 5 (2 + 3) = → $2^{5 \times (2+3)} = 2^{25} = 33554432$

2 y^x 5 × (2 + 3) = → $2^5 \times (2+3) = 2^5 \times 5 = 160$

End of Supplementary 1

4. Memory Calculations

The independently accessible memory is indicated by the three keys: x→M , RM , M+ .
Before starting a calculation clear the memory by pressing c-ce and x→M .

Key in: 12 + 5 = M+ Answer: 17
To subtract key in: 2 + 5 = +/− M+
Answer to this equation: −7
Key in RM to recall memory: 10
Key in: 12 × 2 = x→M
Answer: 24 (Replaces previous amount stored in memory with 24.)
Key in: 8 ÷ 2 = M+
Answer: 4 RM : 28

Note:
- Memory calculations are impossible in the Statistical calculation mode.
- When subtracting a number from the memory, press the +/− and M+ keys.
- For storage memory, see "MULTIPLE STORAGE MEMORIES".

SCIENTIFIC CALCULATIONS

Press the [2ndF] [TAB / F↔E] and [•] keys to calculate in the floating decimal system.
(See "Decimal Places")

1. Second Function

EL-512 has many preprogrammed functions, but the space available on the keys to display all the functions is limited. Most of the keys serve two functions: the first function is displayed on the key itself, the second is printed above the key panel.

The yellow key in the upper left of the calculator marked "2nd F" must be used to designate a second function (The material appearing in brown above or below each key)

Example: (1) [(/ n Σxy]

- Second function: Use the [2ndF] key. ([2ndF] [→r θ])
- First function: Press the [(] key.
- The material appearing below each key is used at the statistical calculation mode.
  - Second function: Use the [2ndF] key. ([2ndF] [Σxy])
  - First function: Press the [n] key.

(2) [r (B) / 1]

- Right side: Hexadecimal number
  Press the [2ndF] [(B)] keys at the normal calculation mode.
- Left side: Statistical calculation key
  Press the [2ndF] [r] keys at the statistical calculation mode.

When the [2ndF] key is depressed, the designation "2nd F" will appear in the lower part of the display. If you press this key in error, press it a second time and the "2nd F" designation will disappear.

In this manual, we will always show key functions as follows;

[2ndF] [sin⁻¹ / sin] → [2ndF] [sin⁻¹] [sin⁻¹ / sin] → [sin]

[2ndF] [r (B) / 1] → [2ndF] [r] or [2ndF] [(B)]

2. Scientific Notation

Decimal Places

The [2ndF] [TAB] keys are used to specify the number of decimal digits in the calculation result. The number of places after the decimal point is specified by the numeral key ([0] ~ [9]) pressed after the [2ndF] [TAB] keys. Carry over will be automatically rounded. For free floating calculation press the [•] key after [2ndF] [TAB] . The designations of decimal places is retained even when the power is turned off.

First Press [2ndF] [TAB] [•] Key in [C·CE] 1.23456789 [=]

Display reads 1.23456789

Press [2ndF] [TAB] [3] , display reads 1.235

Press [2ndF] [TAB] [7] , display reads 1.2345679

Calculate $1.2 \times 10^{-12} \times 4.5 \times 10^{-10}$

Key in: [2ndF] [TAB] [•] 1.2 [EXP] 12 [+/−] [×] 4.5 [EXP] 10 [+/−] [=]

Answer: 5.4-22

If you wish to place a number into the calculator in scientific notation you must use the [EXP] key. If you wish to convert from floating decimal to scientific notation, you must use the key [F↔E] .

Calculate $1.2 \times 10^{20} \times 1.5 \times 10^{5}$

Key in: 1.2 [EXP] 20 [×] 1.5 [EXP] 5 [=]

Answer: 1.8 25 (1.8×10^{25})

Calculate $1.992 \times 10^{33} \times 6.668 \times 10^{-23}$

Key in: 1.992 [EXP] 33 [×] 6.668 [EXP] 23 [+/−] [=]

Answer: 1.3282656 11 (1.3282656×10^{11})

If a calculation is displayed in the floating decimal point system, pushing the [F↔E] key displays the result in scientific notation. Pushing the key again displays the result in the floating decimal point system.

Key in: [C·CE] 1234567898 [=]

Display reads: 1234567898.

Press [F↔E] Display reads 1.2345678 09

Press [F↔E] Display reads 1234567898.

3. Trigonometric functions

The angular mode is designated by the [2ndF] [DRG •] keys. As you press these keys the mode "DEG", "RAD", "GRAD" will appear at the lower part of the display.

Put the angular mode at "DEG".
Calculate: Sin 30° + Cos 40°
Key in the following: 30 [sin] [+] 40 [cos] [=]
Answer: 1.266044443

Calculate: Cos 0.25π
Put the angular mode at "RAD".
Key in: .25 [×] [π] [=] [cos]
Answer: 0.707106781

4. Inverse Trigonometric Functions

Calculate: Sin^{-1} 0.5
Put the angular mode at "DEG".
Key in: .5 [2ndF] [sin⁻¹]
Answer: 30
Calculate: Cos^{-1} −1
Put the angular mode at "RAD".
Key in: 1 [+/−] [2ndF] [cos⁻¹]
Answer: 3.141592654 (Value of π)

(To enter a negative number, press the [+/−] key after numerals.)

5. Hyperbolic and Inverse Hyperbolic Functions

When using the hyperbolic and arc hyperbolic functions "HYP" will appear in the lower part of the display.

Calculate: Sinh 4
Key in: 4 [hyp] [sin]
Answer: 27.2899172
Calculate: $Sinh^{-1}$ 9
Key in: 9 [2ndF] [archyp] [sin]
Answer: 2.893443986

6. Power Functions

Calculate: 20^2
Key in: 20 [x^2]
Answer: 400
Calculate: 3^3 and 3^4
Key in: 3 [y^x] 3 [=]
Answer: 27

Key in: 3 [y^x] 4 [=]
Answer: 81

7. Roots

Calculate: $\sqrt{25}$

Key in: 25 [√]

Answer: 5

Calculate: Cube root of 27

Key in: 27 [2ndF] [$\sqrt[3]{}$]

Answer: 3

Calculate fourth root of 81

Key in: 81 [2ndF] [$\sqrt[x]{y}$] 4 [=]

Answer: 3

8. Logarithmic Functions

Calculate: ln 21, log 173

Natural Logarithms: Key in: 21 [ln]

Answer: 3.044522438

Common Logarithms: Key in: 173 [log]

Answer: 2.238046103

9. Exponential Functions

Calculate: $e^{3.0445}$

Key in: 3.0445 [2ndF] [e^x]

Answer: 20.99952881 (21 as in item "8" above)

Calculate: $10^{2.238}$

Key in: 2.238 [2ndF] [10^x]

Answer: 172.9816359 (173 as in item "8" above)

0. Reciprocals

Calculate: 1/6 + 1/7

Key in: 6 [2ndF] [1/x] [+] 7 [2ndF] [1/x] [=]

Answer: 0.30952381

1. Factorial

Calculate: 69!

Key in: 69 [2ndF] [n!]

Answer: 1.7112245 98 (1.7112245×10^{98})

Note that the Error section deals with the calculation limits of the calculator.

12. Angle/Time conversions

To convert an angle given as degrees/minutes/seconds to its decimal equivalent, it must be entered as integer and decimal respectively.

Convert 12°47'52" to its decimal equivalent

Key in: 12.4752 [→DEG]

Answer: 12.79777778

When converting decimal degrees to the equivalent degrees/minutes/seconds, the answer is broken down: integer portion = degrees; 1st and 2nd decimal digits = minutes; 3rd and 4th digits = seconds; and the 5th through end decimal digits are decimal degrees.

Convert 24.7256 to its degree/minute/second equivalent

Key in: 24.7256 [2ndF] [→DMS]

Answer: 24.433216 or 24°43'32"

A horse has track times of 2 minutes 25 seconds, 2 minutes 38 seconds, and 2 minutes 22 seconds. What is the average running time?

Key in: .0225 [→DEG] [+] .0238 [→DEG] [+] .0222 [→DEG] [=]

Answer 1: 0.123611111

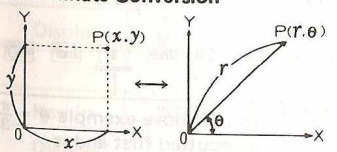
Key in: [÷] 3 [=]

Answer 2: 0.041203704

Key in: [2ndF] [→DMS]

Answer 3: 0.022833333 or the average time is 2 minutes 28 seconds

13. Coordinate Conversion



Rectangular coordinate ⟷ Polar coordinate

$[\rightarrow r\,\theta]$

$r = \sqrt{x^2 + y^2}$

$\theta = \tan^{-1}\frac{y}{x}$

$[\rightarrow xy]$

$x = r\cos\theta$

$y = r\sin\theta$

DEG: $0 \leqq |\theta| \leqq 180$

RAD: $0 \leqq |\theta| \leqq \pi$

GRAD: $0 \leqq |\theta| \leqq 200$

Converting rectangular coordinates to polar $(x, y \rightarrow r, \theta)$

Solve for $x = 6$ and $y = 4$ mode = DEG

Key in: 6 [2ndF] [↕] 4 [2ndF] [→rθ]

Answer: 7.211102551 (r)

Key in: [2ndF] [↕]

Answer: 33.69006753 (θ)

Calculate the magnitude and direction (phase) in a vector $\dot{I} = 12 + j9$

Key in: 12 [2ndF] [↕] 9 [2ndF] [→rθ]

Answer: 15 (r)

Key in: [2ndF] [↕] Answer: 36.86989765 (θ)

Converting polar coordinates to rectangular $(r, \theta \rightarrow x, y)$

Solve for P $(14, \pi/3)$, $r = 14$ $\theta = \pi/3$

Mode = RAD Key in: [C·CE] [π] [÷] 3 [=] [2ndF] [↕] 14 [2ndF] [↕] [2ndF] [→xy]

Answer: 7 (x)

Key in: [2ndF] [↕] Answer: 12.12435565 (y)

In the above example $\theta = \frac{\pi}{3}$ is inputted first and is replaced with $r = 14$ by pushing the [2ndF] [↕] keys after r is inputted.

4. Hexadecimal ↔ decimal notation conversions

Hexadecimal system:

	0	1	2	3	4	5	6	7	8	9
Key in	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Display	0	1	2	3	4	5	6	7	8	9

	10	11	12	13	14	15
Key in	[2ndF] [(A)]	[2ndF] [(B)]	[2ndF] [(C)]	[2ndF] [(D)]	[2ndF] [(E)]	[2ndF] [(F)]
Display	A	b	C	d	E	F

Example: Convert 123 to its hexadecimal equivalent ..... ①

Key in: 123 [2ndF] [→HEX]

Answer: 7b (The symbol "HEX" appears)

Press [2ndF] [→DEC], and "123" will be displayed

Convert 9 A F to its decimal equivalent ..... ②

Key in: 9 [2ndF] [(A)] [2ndF] [(F)] [2ndF] [→DEC]

Answer: 2479

Calculate B2 + 3C =

Key in: [2ndF] [(B)] 2 [+] 3 [2ndF] [(C)] [=] → 238
(Decimal answer)

[2ndF] [→HEX] → EE
(Hexadecimal answer)

Note:
- In hexadecimal number calculation, only the number with through F can be used. (Ex. B2 + 3C)
  Please note that any number without A through F is regarded decimal.
- A hexadecimal number calculation is performed after convertin the entered number to decimal, and the decimal answer displayed.

Remarks:
- Symbol "HEX":
  The symbol "HEX" appears when a hexadecimal answer is displayed.
- Non-operation:

1) In the following case, a conversion can not be performed and an error condition occurs.
   When a number had a decimal and is not a zero in floating decimal system:
   Ex. 123.5 [2ndF] [→HEX]
   When a number exceeds 9999999999:
   Ex. 3 [EXP] 10 [2ndF] [→HEX]
2) The hexadecimal number (A through F) can not be entered in the following cases:
   i) When the [•] or [EXP] key is entered beforehand.
   ii) When minus symbol is displayed.
   iii) When the statistical calculation mode is set.
   (An error occurs.)

- Convertion of negative number:

  Decimal → Hexadecimal

  The EL-512 uses "2's complement" in the internal calculation an displays the results in 16's complement.

  Ex. Key in: 1 [+/−] [2ndF] [•HEX] Answer: FFFFFFFFFf

  Hexadecimal → Decimal

  When 16's complement is converted to decimal, the answer is displayed in negative decimal number.

15. Applications

Ex. 1 Base conversion of logarithm

$$\log_a b = \frac{\log b}{\log a} \qquad a = 3,\ b = 124$$

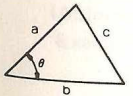
124 [log] [÷] 3 [log] [=]
→ 4.387609364

Ex. 2 Calculates the surface and the volume of the sphere.

$S = 4\pi r^2$, $V = \frac{4}{3}\pi r^3$ Radius $r = 12$ cm

4 [×] [π] [×] 12 [x^2] [=]
→ 1809.557368 (S)
12 [y^x] 3 [×] [π] [×]
4 [÷] 3 [=] → 7238.229474 (V)

Ex. 3 Cosine theorem



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

$a = 14.7$ cm, $b = 17.8$ cm,

$\theta = 43°32'54''$

Calculates the length c

DEG
14.7 [x^2] [+] 17.8 [x^2] [−] 2 [×]
14.7 [×] 17.8 [×] 43.3254 [•DEG]
[cos] [=] [√] → 12.39480134

MULTIPLE STORAGE MEMORIES

The EL-512 has 9 memories ($K_1 \sim K_9$) for storing frequently used constants or results, an an independently accessible memory which has memory plus and memory minus ([2nd] [M+]) function.
By Memory Safe Guard, turning the calculator on and off will not affect the material store in the memory.

Memory $K_1 \sim K_9$
To input a number into a memory press the value followed by [2ndF] [STO] [Kn] and th memory number. Addition or subtraction to a memory is not possible. To recall a valu from a memory press [Kn] and the appropriate memory number. (See Note below) To cle a memory press [0] [2ndF] [STO] [Kn] and the memory number.

Key in: 12 [×] 5 [=] [2ndF] [STO] [Kn] [1]
Answer: 60 (Contents of Memory K_1)
Note: The [Kn] key preceded by the [STO] key can be omitted.
Key in: 300 [÷] [Kn] [1] [=] [2ndF] [STO] [2]
Answer: 5 (Contents of Memory K_2)

Key in: [C·CE] [Kn] [1] [÷] [Kn] [2] [=] [2ndF] [STO] [3]
(In case the [C·CE] key is not used, the contents of the K_1 memory is automatically multiplied by the displayed number "5" when the [1] key is depressed.)
Answer: 12 (Contents of Memory K_3)
Key in: [C·CE] [Kn] [1] [Kn] [2] [Kn] [3]
Answer: 3600
Note:
① Pressing the [Kn] [1] ~ [Kn] [9] when the registered numerical value, the numerical value called from the memory or the calculation result (except for 0) is on display, causes multiplication to occur simultaneously between the numerical values on display and inside the constant memory.
(Automatic multiplication)

Example: Press 20 [2ndF] [STO] [1]
15 [2ndF] [STO] [2]
[Kn] [1]

Note that when you key in the " [1] " your answer is 300.

② Pressing the above keys after [C·CE], [+], [−], [×], [÷], [y^x], [2ndF] [$\sqrt[x]{y}$], [(] or when the calculation result 0 is displayed, causes the memory contents to be called.

Example

You may wish to store any of the following commonly used constants in K_4 to K_7.

K_4	Dielectric Constant of Vacuum	$\epsilon_0 = 8.85419 \times 10^{-12}$
K_5	Gas Constant	$R = 8.2054 \times 10^{-2}$
K_6	Light Velocity of Vacuum	$C = 2.99792 \times 10^{8}$
K_7	Elementary Electric Charge	$e = 1.60219 \times 10^{-19}$

For example:

8.85419	EXP	12	+/−	2ndF	STO	4
8.2054	EXP	2	+/−	2ndF	STO	5
2.99792	EXP	8	2ndF	STO	6	
1.60219	EXP	19	+/−	2ndF	STO	7

Each storage memory operates as a multiplier and storage memories can be automatically multiplied against each other.

A. Coulomb's Law

If you had stored ϵ_0 in K_4 you would calculate Coulomb's Law as follows:

$$F = \frac{1}{4\pi\epsilon_0} \cdot \frac{q_1 \cdot q_2}{r^2} \qquad q_1 = 1c,\ q_2 = 3c,\ r = 4m$$

1 [×] 3 [÷] 4 [x^2] [÷] [(] 4 [π] [Kn] [4] [)] [=]

Answer: 1685165545

Press [F↔E] : 1.6851655 09

B. Gas Equilibrium

If you had stored the gas constant (R) in K_5, you would calculate gas pressure as follows:

$PV = nRT$ $\quad T = 300°K,\ n = 0.5mol,\ V = 10\ell$

.5 [×] 300 [Kn] [5] [÷] 10 [=] Answer: P = 1.23081

C. Metric Conversion

If you wished to convert liters to gallons and miles to kilometers on a regular basis, stor the conversion factors as follows:

Liters to gallons: .264178 [2ndF] [STO] [8]

Miles to kilometers: 1.6093472 [2ndF] [STO] [9]

I purchase 10 liters of gasoline and drive 60 miles. How many kilometers/gallon am getting?

60 [Kn] [9] [÷] 10 [Kn] [8] [=] Answer: 36.5514282 kilometers/gallon

STATISTICAL CALCULATION

The EL-512 has single-variable and double-variable statistical functions, and linear regression function. The statistical mode is obtained by pressing [2ndF] and [STAT] keys (above the [→] key). In this case, while using statistics the symbol [STAT] will appear on the display.

(When the symbol " [LRN] " is displayed, press [2ndF] [LRN] keys, and then press [2ndF] [STAT] keys.)

To clear previous statistical inputs and calculations press [2ndF] and [STAT] keys.

Set the mode by pressing [2ndF] [STAT] keys again.

Reset of the statistical calculation mode can be made by [2ndF] and [STAT] keys.

Note: Pressing the [DATA] will clear the storage memories, K_8 and K_9, as they are used for storing statistical results (n and Σx). The contents of the n (K_8) and Σx (K_9) are retained even when the statistical calculation mode is reset.

1. One-variable statistical calculation

Calculates the following statistics.

(1) n: Number of samples

(2) Σx: Total of samples

(3) Σx^2 : Sum of squares of samples

(4) $\bar{x}$: Mean value of samples $\bar{x} = \dfrac{\Sigma x}{n}$

(5) sx : Standard deviation with population parameter taken to be "n−1".

$$sx = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n-1}}$$

(Used to estimate the standard deviation of population from the sample data extracted from that population.)

(6) σx : Standard deviation with population parameter taken to be "n".

$$\sigma x = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n}}$$

(Used when all populations are taken to be sample data or when finding the standard deviation of population with sample taken to be a population.)

- Data for one-variable statistic calculations are inputted by the following operations.

(1) Data [DATA]

(2) Data [×] Frequency [DATA] (when two or more of the same data are inputted).

Note:

- When the statistical calculations mode is set, the followings can not be performed.

i) Memory calculation with an independently accessible memory and storage memories K_8 and K_9.

ii) Coordinate conversion

iii) Calculation including parenthesis.

iv) Hexadecimal ↔ decimal conversion.

- The followings can be used as the input data in statistical calculation:

i) Entry number

ii) Calculated result of the functions which can be used in the chain calculation.

2. Single Variable Statistics

Calculates standard deviation, mean, and variance $(sx)^2$ from the following data:

Value	35	45	55	65
Frequency	1	1	5	2

As each sample is entered the number of that sample will appear on the right hand side of the display.

Mode: STAT, Floating decimal point system

Key in:		Display
35	DATA	1
45	DATA	2
55 x 5	DATA	7
65 x 2	DATA	9

	Key in:	Display:
Mean:	2ndF $\bar{x}$	53.88888889
Standard Deviation:	2ndF Sx	9.279607271
Variance:	x^2 =	86.11111111

Correct Data (CD): The last entry above is an error and must be changed to 60 x 2.

Key in:	Display
65 X 2 2ndF CD	7
60 X 2 DATA	9

Note: When you correct the mis-entry before pressing the DATA key, use CD key.

3. Two-Variable Statistics and Linear Regression.

In addition to the same statistical functions for Y as for X in single-variable statistics, the sum of the products of samples ΣXY is added in two-variable statistics.

In Linear Regression there are three important values; r, a, and b. The correlation coefficient r shows the relationship between two variables for a particular sample. The value of r is between −1 and 1. If r equals −1 or 1, all points on the correlation diagram are on a line. The further the value of r is from −1 and 1, the less the points are massing about the line and the less reliable is the correlation. If r is more than 0, it shows a positive correlation (Y is in proportion to X) and if r is less than 0, it is a negative correlation (Y is inverse proportion to X).

The equation for the straight line is $Y = a + bX$. The point at which the line crosses the Y axis is a. The slope is b.

r Correlation coefficient

$$r = \frac{S_{xy}}{\sqrt{S_{xx} \cdot S_{yy}}}$$

a $a = \bar{y} - b\bar{x}$

b $b = \frac{S_{xy}}{S_{xx}}$

Coefficient of linear regression equation $Y = a + bx$

$$\begin{cases} S_{xx} = \Sigma x^2 - \dfrac{(\Sigma x)^2}{n} \\ S_{yy} = \Sigma y^2 - \dfrac{(\Sigma y)^2}{n} \\ S_{xy} = \Sigma xy - \dfrac{\Sigma x \cdot \Sigma y}{n} \end{cases}$$

x' $x' = \dfrac{y - a}{b}$ Estimated value (the value of x is estimated from that of y.)

y' $y' = a + bx$ Estimated value (the value of y is estimated from that of x.)

- Data for two-variable statistic calculations are inputted by the following operations.
  (1) Data (x) [x,y] Data (y) [DATA]
  (2) Data (x) [x,y] Data (y) [X] Frequency [DATA]

Example: If we know a student's mark in mathematics, can we predict the mark in English?

The exam marks for six students chosen at random are given in the following table:

Mode: STAT, Floating decimal point system

Student No.	Mark in Math.	Mark in English
n	X	Y
1	82	79
2	53	50
3	61	87
4	74	96
5	51	73
6	51	73

Key in:				Display	
82	[x,y]	79	[DATA]	1	
53	[x,y]	50	[DATA]	2	
61	[x,y]	87	[DATA]	3	
74	[x,y]	96	[DATA]	4	
51	[x,y]	73 x 2	[DATA]	6	(Note: to input multiple identical samples proceed as indicated)
[2ndF]	[r]		.571587901		
[2ndF]	[a]		34.26190476		
[2ndF]	[b]		.678571429		

The value of r of .57 indicates that the correlation is marginal. The equation for the straight line for this data is Y = 34.26 + .68X.

If we had a student whose mark in mathematics was 90, based on this analysis, what mark would the student have in English?

90 [2ndF] [y'] 95.33333333

If we had a student whose mark in English was 80, based on this analysis, what mark would the student have in mathematics?

80 [2ndF] [x'] 67.40350877

MULTIPLE FORMULA RESERVE

1. Basic Programming

Mathematical formulas can be stored by using the LEARN MODE. Capacity is 128 steps. Formulas can be recalled at any time and they are protected by Memory Safe Guard.

MULTIPLE FORMULA RESERVE KEYS:

EL-512 has the formula reserve memory capacity of 128 steps which can be divided into a maximum of 4 areas for formula storage. Therefore, 4 formulas can be stored.

When the number of steps exceeds 128, the error is occurred and the error symbol "E" is displayed. To clear the error depress the [C·CE] key.

The special keys to be used in this mode are:

[2ndF] [LRN] : Used to begin or end the mode for entering formulas.
" LRN " indicator is displayed.

[1:] , [2:] ,
[2ndF] [3:] , [2ndF] [4:] : Used to designate a formula number.
Pressing the key executes the calculation according to a formul stored.

[COMP] : After formula number is designated, pressing this key will produce the variable for which a value needs to place in the calculator. After all value have been inputted pressing [COMP] results in the answer. [COMP] restarts calculations after the [2ndF] [LOOK] have been used.

[(x)] : To enter variables in a formula in the LEARN MODE. The variable symbol is displayed with the number of the variable as entered [1] [2] [3].

[2ndF] [LOOK] : ① To display more than 2 answers, enter the [2ndF] [LOOK] key operation in the formula where necessary for indication.
② The answers will be displayed on the LOOK indicator during calculation.

2. HOW TO STORE A FORMULA:

Procedure:

① Set the EL-512 at the LEARN mode by depressing the [2ndF] and [LRN] keys. Make sure that the symbol " LRN " is displayed. (If the symbol " STAT " is displayed depress the [2ndF] and [STAT] keys. Then, depress the [2ndF] and [LRN] keys.)
(When the LEARN mode is set, the 4 digits of the symbol "■" are flashing to indicate that the formula number should be entered.)

② Enter the formula number by depressing the formula designation key (1: , 2: , 2ndF 3: or 2ndF 4:). (The symbol "■" is displayed in upper part of the display to show the designated formula number.)

③ Enter the formula.

To correct mis-operation in the course of a formula entry, press the formula designation key (Example: For formula 1, press the 1:) and enter the correct formula from the beginning.

④ Depress the 2ndF and LRN keys to end the formula entry. (The symbol " LRN " disappear.)

Example 1:

x + 2y + 3z x = 20 y = 30 z = 40

Input Procedure: 2ndF LRN 1:

(x) + 2 × (x) + 3 × (x) = 2ndF LRN

3. HOW TO USE A FORMULA:

Procedure:

① Make sure that the symbol " LRN " or " STAT " is not displayed. If the symbol " LRN " or " STAT " is displayed, depress the 2ndF LRN or 2ndF STAT keys respectively.

② Depress the formula designation key. The symbol "■" is displayed to show the designated formula number and the calculation is started.

In case of above example 1:

Solution:

Press 1:	Display: [1]	Key in:	20
Press COMP	[2]	Key in:	30
Press COMP	[3]	Key in:	40
Press COMP	Answer: 200		
Press COMP	[1] (Enter new values for x, y, and z)		

4. HOW TO CLEAR A FORMULA:

Procedure:

① Set the EL-512 at the LEARN mode by depressing the 2ndF and LRN keys. (When the symbol " LRN " is displayed, skip this step.)

② To clear a formula:
Depress one of the formula designation keys. (Example: For formula 1, press the 1: .)

To clear all formulas:
Depress the [1:], [2:], [2ndF] [3:] and [2ndF] [4:] keys.

Example 2: MULTIPLE FORMULA RESERVE
(When 4 kinds of formula are entered simultaneously:)

[Input]

Formula 1 — **Circumference and area of a circle**

$l = 2\pi r$ $S = \pi r^2$ $r = 1, 2, 3$

Note: The first value of the variable may be inputted directly followin
the variable sign.

Input Procedure: [2ndF] [LRN] [1:]
2 [×] [π] [×] [(x)] 1 [x→M] [=]
Answer = 6.283185307 (and 1 is stored in memory
[2ndF] [LOOK] To display intermediate answer
[RM] [x²] [×] [π] [=]
Answer = 3.141592654

Formula 2 — **Automatic Incrementing**

To solve a formula in which the variable is increased by the same amount each time, it is not necessary to place a value in the equation for each solution. Place the amount to be incremented in Memory and each time [COMP] is pressed the value of X will be automatically increased by the value in memory.

a. $f(x) = 2x^2 + 7x + 9$ $x = 1, 2, 3, \cdots\cdots$

Procedure:

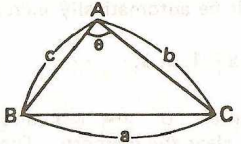
[2:] 0 [x→M] [C·CE] [C·CE] (Enter [0] [x→M] [C·CE] and [C·CE] in that order to clear the memory. The step number does not count up.)

1 [M+] 2 [×] [RM] [x²] [+] 7 [×] [RM] [+] 9 [=] (f(1) = 18)

Formula 3 — **Cosine Theorem**

Angle Mode: DEG (Set DEG mode before inputting the first formula)

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



Case A. b = 2, c = 3, $\theta = 60°$

Case B. b = 10, c = 12, $\theta = 30°$

Procedure: 2ndF 3:

(x) 2 2ndF STO 1 x^2 +

(x) 3 2ndF STO 2 x^2 −

2 Kn 1 Kn 2 × (x)

60 cos = $\sqrt{\ }$

Case A answer a = 2.645751311

Formula 4 — **Business Application (Trade discounts)**

There are many business applications for which the EL-512 is an ideal tool. For example, a series of discounts from the list price are offered. They are 35%, 3%, 2%. Calculate the final price for a series of prices starting at $10 and increasing by increments of $10.

The equivalent discount is:

(1-first discount) x (1-second discount) x (1-third discount)

Procedure:

2ndF 4: 0 x→M C·CE C·CE

10 M+

.65 × .97 × .98 × RM = Answer: 6.1789

2ndF LRN

[Solution]

Formula 1: 1: 2 COMP Answer: 12.56637061 Circumferance @ r = 2 ($2\pi \times 2$)

COMP 12.56637061 Area @ r = 2 ($\pi \times 2^2$)

COMP 3 COMP Answer: 18.84955592 Circumferance @ r = 3

COMP 28.27433388 Area @ r = 3

→ To proceed the calculation in the same formula with different variables, just press the COMP key. (In the above case, the formula designation key can be also used.)

Formula 2: 0 [x→M] (Clear the memory before starting the formula 2.)

[2:] Display: 18 (f(1))

[COMP] 31 (f(2))

[COMP] 48 (f(3))

Formula 3: [2ndF] [3:] 10

[COMP] 12

[COMP] 30

[COMP] Case B

answer a = 6.01281158

Formula 4: 0 [x→M]

[2ndF] [4:]

Next, press [COMP] to get the final discounted price for each increment

Retail Price	Discounted Price
$10	$6.1789
$20	12.3578
$30	18.5367
$40	24.7156
$50	30.8945
$60	37.0734
$70	43.2523
$80	49.4312
$90	55.6101
$100	61.789

5. Program Steps

The maximum storage capacity of the EL-512 is 128 steps. If the number of steps is exceeded an error is encountered.

The number of steps used in the preceding examples were:

		No. of Steps
1. Example 1:		11
2. Example 2:	Formula 1	14
	Formula 2	14
	Formula 3	21
	Formula 4	18

- The following keys does not count up as program step:

  [2ndF] , [2ndF] [LRN] , [archyp / hyp]

  [0] ~ [9] , [•] , [EXP] , [C·CE] , [⟶] or [+/−] key located just after the [(x)] key.

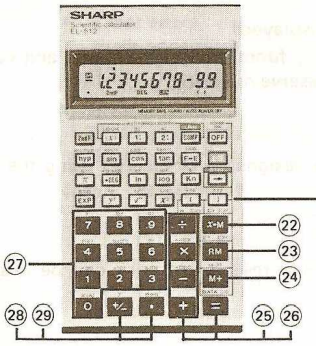
- Example of step

Number of step		
0	1	2
[2ndF] [LRN] , [2ndF] , [hyp]	[1:] , [2ndF] [3:] , [2ndF] [sin] , [2ndF] [archyp] [sin] , [0] ~ [9]	[2ndF] [STO] [1] , [Kn] [1] , [2ndF] [TAB] [3]

- If an error occurs in key operation during formula storage, press the [C·CE] key and designate the formula number again. Then enter the formula from the beginning.
- When the error symbol "E" is displayed depress the [C·CE] key to clear the error conditions.

  For example: When the non-stored formula key is depressed, or when the [COMP] key is depressed before operating the [1:], [2:], [2ndF] [3:] or [2ndF] [4:] keys.

THE KEYBOARD



1 C·CE
2 OFF
3 2ndF
4 LOOK (x)
5 3: 1: 4: 2:
6 LRN COMP
7 a·chyp hyp
8 sin⁻¹ sin cos⁻¹ cos tan⁻¹ tan
9 TAB F↔E
10 n! π
11 °DMS °DEG
12 eˣ ln
13 10ˣ log
14 ↕ Kn
15 STAT →
16 STO EXP
17 ˣ√y yˣ
18 3√ √
19 1/x x²
20 °r'θ (n Σxy
21 °xy) Σx Σx²

MODES

There are three type of modes:

Normal calculation mode:

(The symbol " STAT " and " LRN " are not displayed)

The mode for general arithmetic calculations, functional calculations and calculations based on the formulas stored in the formula reserve memory.

Statistical calculation mode:

(Displays " STAT ")

The mode for statistical calculations can be designated or cleared using the 2ndF STAT keys.

Learn mode:

(Displays " LRN ")

The mode for formula storage in the formula reserve memory can be designated or cleared using the 2ndF LRN keys.

OPERATING CONTROLS

Power on and clear/clear entry key

When this key is depressed, the calculator is turned on.

- **Clear entry**

  Push once during a calculation and the last entry is cleared.

  123 + 455 C·CE 456 = → 579.

- **Clear**

  When pushed twice during operation it clears the calculator except for the memory.

Note: When the formula is designated by the 1: ~ 2ndF 4: in LEARN mode, the C·CE key works as follows:

(1) When the C·CE is used as clear entry key, stores the clear entry function in the memory.

(2) When the C·CE is used as all clear key, clears the formula designated except for formula number.

② OFF **Power off key**
When this key is depressed, the calculator is turned off.

③ 2ndF **2nd function designation key**

④ LOOK (x) **Variable designation/intermediate result display key**

(x) : Used to specify a variable when a calculating formula is stored in the LEARN mode. The key must be pushed before entering a variable. Specifying a variable by the (x) key temporarily stops the execution of a calculation subjected to a stored mathematical formula, enabling the entry of a variable.

2ndF LOOK : Refer to page 49.

⑤ 3: 4: 1: 2: **Formula designation keys**

1: 2:
2ndF 3: , 2ndF 4: } Example: Refer to page 48.

⑥ LRN COMP **Compute and learn key**

COMP : This key is used to restart a calculation which is temporarily interrupted due to entry of a variable or a display of an intermediate result.

2ndF LRN : Set or reset the EL-512 at the LEARN mode.

⑦ archyp hyp **Hyperbolic/arc hyperbolic key**
Example: Refer to page 25.

⑧ $\sin^{-1}$ sin, $\cos^{-1}$ cos, $\tan^{-1}$ tan **Trigonometric/inverse trigonometric function key**
Example: Refer to page 24.

⑨ TAB F↔E **Display format exchange/Tabulation key**

F↔E : **When a calculation result is displayed in the floating decimal point system,** pushing the key displays the result in the scientific notation system.

Pushing the key once more displays the result in the floating decimal point system again.

2ndF TAB : Refer to page 22.

⑩ n! / π **Pi/Factorial Key**

π : The constant π ($\pi \fallingdotseq 3.141592654$) is entered.
Example: Refer to page 24.

2ndF n! : Calculates the factorial of the displayed number.
Factorial of $n(n!) = n \cdot (n-1) \cdot (n-2) \cdots\cdots 2 \cdot 1$

⑪ ←D.MS / →DEG **Degree/minute/second ↔ Decimal degrees conversion key**
Example: Refer to page 28.

⑫ e^x / ln **Natural logarithm/antilogarithm key**

ln : Used to obtain the logarithm base e ($e \fallingdotseq 2.718281828$).
Example: Refer to page 26.

2ndF e^x : Calculates the antilogarithm base e of the displayed number.
Example: Refer to page 27.

⑬ 10^x / log **Common logarithm/antilogarithm key**

log : Used to obtain the logarithm with the base of 10.
Example: Refer to page 26.

2ndF 10^x : Calculates the antilogarithm with the base of 10.
Example: Refer to page 27.

⑭ ↕ / Kn **Storage memory/exchange key**

Kn : Example: Refer to page 36.

2ndF ↕ : Used to exchange the number being displayed with the number stored in the working register. ($x \leftrightarrow y$)

⑮ STAT / → **Right shift/statistical calculation mode key**

→ : Example

	Key in		Display
①	12356 → →	→	123.
	45	→	12345.
②	5 EXP 24 → →	→	5. 00
	35	→	5. 35

[2ndF] [STAT] : Statistical program will be activated.
When the calculator is set to the statistical calculation mode through this key, the symbol " STAT " appears, and at the same time the entire machine is cleared. Meanwhile, in the statistical calculation mode the [(] , [)] , [x→M] , [RM] and [M+] keys work as the [n] , [Σx] , [Σy] , [(x,y)] and [DATA] keys, respectively. And pushing these keys immediately after the [2ndF] key they work as the [Σxy] , [Σx²] , [Σy²] , (inoperative) and [CD] keys.

⑯ STO / [EXP] **Enter exponent and store key**

[EXP] : Example: Refer to page 23.

[2ndF] [STO] : Example; Refer to page 36.

⑰ $\sqrt[x]{y}$ / [y^x] **$Y^X/\sqrt[X]{Y}$ key**

[y^x] : Raises a number to a power.

[2ndF] [$\sqrt[x]{y}$] : Calculates the Xth root of Y.
Example: Refer to page 25 and 26.

⑱ $\sqrt[3]{\ }$ / [$\sqrt{\ }$] **Square root/cube root key**

[$\sqrt{\ }$] : Calculates the square root of the number displayed.
Example: Refer to page 26.

[2ndF] [$\sqrt[3]{\ }$] : Calculates the cube root of the number displayed.
Example: Refer to page 26.

⑲ 1/x / [x^2] **Square/reciprocal key**

[x^2] : Calculates a square of the number displayed.
Example: Refer to page 25.

[2ndF] [1/x] : Calculates the reciprocal of the number displayed.
Example: Refer to page 27.

⑳ →rθ / [(] / n Σxy **Open parenthesis/rectangular coordinate → polar coordinate conversion/statistical calculation key**

[(] : Used to open parenthesis.
Example: Refer to page 13.

[2ndF] [→rθ] : Converts rectangular coordinate into polar coordinate.
Example: Refer to page 29.

- When the statistical mode is set,

n : Displays the number of samples entered.

2ndF Σxy : Used to obtain the sum of the products of data x and y in two-variable statistical calculation.

→xy

(21)) **Close parenthesis/polar coordinate → rectangular coordinate conversion/statistical calculation key**

$\Sigma x\ \Sigma x^2$

) : Used to close parenthesis.
Example: Refer to page 13.

2ndF →xy : Converts polar coordinate into rectangular coordinate.
Example: Refer to page 30.

- When the statistical calculations mode is set,

Σx : Used to obtain the sum of data (Σx).

2ndF Σx^2 : Used to obtain the sum of squares of data (Data: x).

(22) $x \rightarrow M$ **Memory-in/Σy Σy^2 key**

$\Sigma y\ \Sigma y^2$

$x \rightarrow M$: Clears the number in the memory and then store the number being displayed in the memory.
To clear the memory depress the C·CE key followed by the $x \rightarrow M$ key.

- When the statistical mode is set,

Σy : Used to obtain the sum of data (Data: y)

2ndF Σy^2 : Used to obtain the sum of squares of data (Data: y)

(23) RM **Recall memory/statistical calculation key**

(x,y)

RM : Displays the contents of the memory. The contents of the memory remain unchanged after this key operation.

- When the statistical mode is set,

(x,y) : Used to distinguish data x and data y in the two-variable statistical calculation.
Example: Refer to page 46.

(24) M+ **Memory plus/DATA CD key**

DATA CD

M+ : Used to add the number being displayed or a calculated result to the

contents of the memory.
When subtracting a number from the memory, depress the [+/−] and [M+] keys in this order.

- When the statistical mode is set,

[DATA] : Used to enter the data (numbers).

[2ndF] [CD] : Used to correct the mis-entry. (delete function).

(25) [+] [−] [×] [÷] (→DEC, →HEX)

Arithmetic functions/Hexadecimal ↔ decimal notation conversions keys
Depressed for addition, subtraction, multiplication and division.

[2ndF] [→HEX] : Converts the number displayed in base 10 into a number in base 16.

[2ndF] [→DEC] : Converts the number displayed in base 16 into a number in base 10.

(26) [=] **Equals key**
Completes four arithmetic calculations (+, −, ×, ÷), $\sqrt[x]{y}$ and Y^X calculations.

(27) [0] ~ [9] (x'(A), σy)

Numeral and statistical calculations keys
Used to enter numbers.

Hexadecimal entry:

0 ~ 9 → [0] ~ [9]

10 ~ 15 → [2ndF] (A) ~ [2ndF] (F)

- When the statistical mode is set,

[x'] : Used to obtain the estimated value of x.

[r] : Used to obtain the correlation coefficient in two-variable statistical calculation.

[a] : Used to obtain the constant a of the linear regression equation $y = a + bx$.

[b] : Used to obtain the coefficient b of the linear regression equation $y = a + bx$.

[$\bar{x}$] : Used to obtain the mean value of data (Data: x)

[sx] : Used to obtain the standard deviation (sx) of the sample of data (x).

[σx] : Used to obtain the standard deviation (σx) of the population of data (x).

[$\bar{y}$] : Used to obtain the mean value of data (Data: y)

[Sy] : Used to obtain the standard deviation (sy) of the sample of data (y).

[σy] : Used to obtain the standard deviation (σy) of the population of data (y).

(28) y' [+/−]

Change sign and statistical calculation key

[+/−] : Changes the sign of the number displayed from a positive to a negative or vice versa.

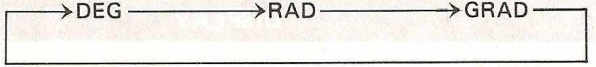
[y'] : When the calculator is set at the statistical calculation mode: Used to obtain the estimated value of y.

(29) DRG [•]

Decimal point and Degree/Radian/Grad selection key

[•] : Example 12.3 → [1] [2] [•] [3]
0.7 → [•] [7]

[2ndF] [DRG] : Used for calculation of trigonometric, inverse trigonometric and coordinate conversion. The [2ndF] [DRG] keys change the angular mode.



(Press [2ndF] [DRG])

Ex. DEG → GRAD: Depress the [2ndF] [DRG] keys twice.

"DEG" mode – Entires and answers are in decimal degrees.
"RAD" mode – Entries and answers are in radians.
"GRAD" mode – Entries and answers are in grads. ($100^g = 90^\circ = \frac{\pi}{2}$).

DISPLAY

(1) Display format

(Floating decimal system)

(Scientific notation system)

(2) Symbols and indicators

−: **Minus symbol**
Indicates that the number in the display following the "−" is a negative.

M : **Memory symbol**
Appears when a number is stored in the memory.

E: **Error symbol**
Appears when an overflow or an error is detected.

●: **Battery indicator**
The battery indicator is a grey dot located at the left side of the display. When this dot is not on, the batteries must be replaced.

2ndF: **2nd function designation symbol**
Appears when the 2nd function is designated.

HYP: **Hyperbolic function designation symbol**
Appears when hyperbolic function is designated.

DEG: **Degree mode symbol**
Appears when the degree mode is designated.

RAD: Radian mode symbol
Appears when the radian mode is designated.

GRAD: Grad mode symbol
Appears when the grad mode is designated.

LRN : LEARN mode symbol
Appears when learn mode is set.

LOOK: Intermediate result indication symbol
Appears when the 2ndF LOOK keys are depressed in the learn mode or when an answer is displayed during calculation.

STAT : Statistical calculation mode symbol
Appears when statistical calculation mode is set.

( ): Parenthesis symbol
Appears when a calculation with parenthesis is performed by depressing the (key.

HEX: Hexadecimal symbol
Appears when an answer in hexadecimal notation is displayed.

[0] : Variable input symbol
Appears when the [x] key is pressed in the LEARN mode or when the entry of a variable is required while a calculation is executed according to a stored mathematical formula. The number in brackets shows where a variable concerned standards in the list of variables, randing from "1" to "9" and "A" ~ "F".
For variable No. 16 and the subsequent, the symbol "-" is displayed instead of a numeral.

▮: Formula number indicator
Appears when formula reserve function is used.

3. **Display system**
This machine displays a calculation result (x), if it is within the following range, in the floating decimal point system.

$$0.000000001 \leqq |x| \leqq 9999999999$$

And otherwise the machine displays $|x|$ in the scientific notation system. (When the number of decimal digits is fixed at 0 to 9, a calculation result is displayed, even if it is below 0.000000001, in the floating decimal point system.) However, a calculation result within the above range is also capable of being displayed in the scientific notation system by pressing the [F⇔E] key.

Ex. (1) 1111111111 [×] 5 [=] → 5555555555.
[F⇔E] → 5.5555555 09
Mantissa 8 digits; Exponent 2 digits

Ex. (2) 5 [EXP] 6 [+/−] [÷] [3] [=] → 0.000001667 ①
[F⇔E] → 1.6666666 − 06 ②
[F⇔E] → 0.000001667

The machine carries out all calculations in exponent form ($A \times 10^B$) and computes the mantissa of a result up to 12 digits. (In the above example (2)),

$1.66666666666 \times 10^{-6}$
12 digits

And the mantissa is displayed after rounded at the 11th place (Floating decimal system) or at a decimal place one lower than the specified.

① $0.0000016666\overset{7}{6} \times 10^{00}$
10 digits (Displayed)

② $1.6666666666\overset{7}{6} \times 10^{-06}$
8 digits (Mantissa) (Displayed)
2 digits (Exponent) (Displayed)

End of supplementary 2

ERRORS

In the case of an error, the display will show "E". An error will be caused by a calculations or instruction beyond the capacity of the machine. An error can be cleared by the [C·CE] key. There are three types of error conditions: overflow, underflow, and incorrect operation.

Supplementary 3 — Error Conditions

1. An overflow error occurs when the absolute value of a calculation, or the result in memory is greater than $9.999999999 \times 10^{99}$. (Overflow error)
2. The underflow error occurs when the value of a calculation is less than 1×10^{-99}. In this case, the calculator assumes the value is 0 and the calculation may continue instead of registering an error and stopping the calculation.
3. When a number is divided by 0 (zero) (Ex. 5 [÷] 0 [=])
4. When the pending operation exceeds 8 levels or when the [(] key is depressed 16 times or more in 1 level.

5. For scientific functions an error occurs when the calculations exceed the following ranges:
6. For the errors in formula reserve and hexadecimal ⟷ decimal conversion, see each section.

CALCULATION RANGE

- The entry and four (4) arithmetic calculations:
  Entry, 1st operand, 2nd operand: $\pm 1 \times 10^{-99} \sim \pm 9.999999999 \times 10^{99}$ and 0
  Calculated result: $\pm 1 \times 10^{-99} \sim \pm 9.9999999 \times 10^{99}$ and 0

  Note: When the absolute value of a calculation in less than 1×10^{-99}, the calculator assumes the value is 0.

- Scientific and special functions:

Functions	Dynamic range
$\sin x$ $\cos x$ $\tan x$	DEG: $\lvert x \rvert < 1 \times 10^{10}$ RAD: $\lvert x \rvert < \frac{\pi}{180} \times 10^{10}$ GRAD: $\lvert x \rvert < \frac{10}{9} \times 10^{10}$

Functions	Dynamic range
$\sin x$ $\cos x$ $\tan x$	In $\tan x$, however, the following cases are excluded. DEG: $\lvert x \rvert = 90\ (2n - 1)$ RAD: $\lvert x \rvert = \frac{\pi}{2}(2n - 1)$ n = integer GRAD: $\lvert x \rvert = 100\ (2n - 1)$
$\sin^{-1} x$ $\cos^{-1} x$	$-1 \leqq x \leqq 1$
$\tan^{-1} x$	$\lvert x \rvert < 1 \times 10^{100}$
$\ln x$ $\log x$	$1 \times 10^{-99} \leqq x < 1 \times 10^{100}$
e^x	$-1 \times 10^{100} < x \leqq 230.2585092$
10^x	$-1 \times 10^{100} < x < 100$

Functions	Dynamic range
y^x	• $y > 0$: $-1 \times 10^{100} < x \log y < 100$ • $y = 0$: $x \geqq 0$ • $y < 0$: x : integer $-1 \times 10^{100} < x \log \lvert y \rvert < 100$
$\sqrt[x]{y}$	• $y > 0$: $-1 \times 10^{100} < \frac{1}{x} \log y < 100,\ x \neq 0$ • $y = 0$: $x > 0$ • $y < 0$: x : integer $(x \neq 0)$ $-1 \times 10^{100} < x \log \lvert y \rvert < 100$
$\sqrt[3]{x}$	$\lvert x \rvert < 1 \times 10^{100}$
$\sinh x$ $\cosh x$ $\tanh x$	$-227.9559242 \leqq x \leqq 230.2585092$
$\sinh^{-1} x$	$\lvert x \rvert < 1 \times 10^{50}$

Functions	Dynamic range
$\cosh^{-1} x$	$1 \leqq x < 1 \times 10^{50}$
$\tanh^{-1} x$	$\lvert x \rvert < 1$
$\sqrt{x}$	$0 \leqq x < 1 \times 10^{100}$
x^2	$\lvert x \rvert < 1 \times 10^{50}$
$\frac{1}{x}$	$\lvert x \rvert < 1 \times 10^{100}$ $x \neq 0$
n!	$0 \leqq n \leqq 69$ (n: integer)
→DEG →DMS	$\lvert x \rvert < 1 \times 10^{100}$
$x, y \rightarrow r, \theta$	$\lvert x \rvert < 1 \times 10^{50}$ $\lvert y \rvert < 1 \times 10^{50}$ $0 < x^2 + y^2 < 1 \times 10^{100}$

Functions		Dynamic range
$r, \theta \rightarrow x, y$		$0 \leqq r < 1 \times 10^{100}$
→HEX		$-9999999999 \leqq x \leqq 9999999999$ x: integer
→DEC		$0 \leqq x \leqq 2540BE3FF$ $FDABF41C01 \leqq x \leqq FFFFFFFFFF$ x: integer
Statistical calculation	Data CD	$\lvert x \rvert < 1 \times 10^{50}$ $\lvert y \rvert < 1 \times 10^{50}$ $\lvert \Sigma x \rvert < 1 \times 10^{100}$ $\Sigma x^2 < 1 \times 10^{100}$ $\lvert \Sigma y \rvert < 1 \times 10^{100}$ $\Sigma y^2 < 1 \times 10^{100}$ $\lvert \Sigma xy \rvert < 1 \times 10^{100}$ $\lvert n \rvert < 1 \times 10^{100}$
	$\bar{x}$	$n \neq 0$

Functions		Dynamic range
Statistical calculation	Sx	$n \neq 1$ $0 \leqq \dfrac{\Sigma x^2 - n\bar{x}^2}{n-1} < 1 \times 10^{100}$
	σx	$n \neq 0$ $0 \leqq \dfrac{\Sigma x^2 - n\bar{x}^2}{n} < 1 \times 10^{100}$
	$\bar{y}$	$n \neq 0$
	Sy	$n \neq 1$ $0 \leqq \dfrac{\Sigma y^2 - n\bar{y}^2}{n-1} < 1 \times 10^{100}$
	σy	$n \neq 0$ $0 \leqq \dfrac{\Sigma y^2 - n\bar{y}^2}{n} < 1 \times 10^{100}$

Functions		Dynamic range
Statistical calculation	r	$n \neq 0$ $0 < \lvert (\Sigma x^2 - n\bar{x}^2) \cdot (\Sigma y^2 - n\bar{y}^2) \rvert < 1 \times 10^{100}$ $\left\lvert \Sigma xy - \dfrac{\Sigma x \cdot \Sigma y}{n} \right\rvert < 1 \times 10^{100}$ $\left\lvert \dfrac{\Sigma xy - \dfrac{\Sigma x \cdot \Sigma y}{n}}{\sqrt{(\Sigma x^2 - n\bar{x}^2) \cdot (\Sigma y^2 - n\bar{y}^2)}} \right\rvert < 1 \times 10^{100}$
	b	$n \neq 0$ $0 < \lvert \Sigma x^2 - n\bar{x}^2 \rvert < 1 \times 10^{100}$ $\left\lvert \Sigma xy - \dfrac{\Sigma x \cdot \Sigma y}{n} \right\rvert < 1 \times 10^{100}$ $\left\lvert \dfrac{\Sigma xy - \dfrac{\Sigma x \cdot \Sigma y}{n}}{\Sigma x^2 - n\bar{x}^2} \right\rvert < 1 \times 10^{100}$

Functions		Dynamic range
Statistical calculation	a	a is the same condition as b, and $\lvert \bar{y} - b\bar{x} \rvert < 1 \times 10^{100}$
	y'	$\lvert a + bx \rvert < 1 \times 10^{100}$
	x'	$\left\lvert \frac{y-a}{b} \right\rvert < 1 \times 10^{100}$

Note: As a rule, the error of functional calculations is less than ±1 at the lowest digit of a displayed numerical value (at the lowest digit of mantissa in the case of scientific notation system) within the above calculation range.
In the calculation of sinh x, tanh x, $\sinh^{-1} x$ and $\tanh^{-1} x$, x is a singular point when it is 0 (zero). Near this point the error is accumulated, reducing the accuracy.

SPECIFICATIONS

Model:	EL-512
Display capacity:	Floating decimal point display: 10 digits or Exponent display: Mantissa 8 digits Exponent 2 digits
Symbols and indicators:	Minus symbol appears both in mantissa and exponents portion, etc. See "DISPLAY"
Calculations:	Four arithmetic calculations, constant calculation, memory calculation, degree/minute/second ⟷ decimal degrees conversion, trigonometric function, inverse trigonometric function, logarithmic function, exponential, square and power, cube root, Xth root of Y ($\sqrt[x]{y}$), square root, reciprocal, factorial, coordinates conversion, statistical calculation, hyperbolic and inverse hyperbolic functions, hexadecimal and decimal notations conversion, etc.
Memory:	9 storage memories 1 independently accessible memory
Formula reserve memory:	128 steps (can be divided into a maximum of 4 areas), LEARN system (for formula storage during calculation).

Component:	LSI etc.
Display:	Liquid crystal (FEM type)
Power supply:	3V ⎓ (DC): Alkaline manganese battery (Type: LR-44) x 2 or Silver oxide battery (Type: G-13) x 2.
Operating time:	Alkaline manganese battery (LR-44): Approx. 1,000 hours or Silver oxide battery (G13): Approx. 3,000 hours, Display 555555, at the ambient temperature: 20°C (68°F). The operating time slightly changes depending on the type of battery or the way of use.
Ambient temperature:	0°C ~ 40°C (32° ~ 104°F)
Power consumption:	3V ⎓ (DC): 0.0002W
Dimensions:	69 (W) x 128 (D) x 8.5 (H) mm 2-23/32"(W) x 5-1/32"(D) x 11/32"(H)
Weight:	Approx. 70g (0.15 lbs.)
Accessories:	Alkaline manganese battery (LR-44) (Built-in) x 2, wallet and instruction manual

End of Supplementary 3

BATTERY REPLACEMENT

When the battery indicator is out, replace the batteries*.

1. Turn off the calculator.
2. Remove the screws from the back cover with a small screw driver (Fig. 1).
3. Replace the batteries. (Fig. 2) (+ side must be up)
4. Hook the tabs of the back cover into the slits of the calculator proper. (Fig. 3)
5. Push the back cover in slightly while replacing the screws.
6. After the replacement, press the [OFF] and [C·CE] keys in this order to clear the calculator.

   When the batteries are correctly installed " • DEG 0." will be displayed. (If the display shows nothing or a meaningless symbol, or the keys become inoperative, remove the batteries and install them again. Press the [OFF] and [C·CE] keys in this order and check the display again.)

Note:
- Wipe off the surface of the new batteries with dry cloth and then install the batteries as shown in Fig. 2.
- Always replace both of the batteries at the same time.

* Battery: Alkaline manganese battery (Type: LR-44) x 2 or silver oxide battery (Type: G13) x 2 (Eveready model S76, Mallory model MS76 and Ray-O-Vac model RS76 or equivalent should be used.)

Batteries may be obtained where you purchased your calculator or at most retail outlets for calculators, watches, or cameras..

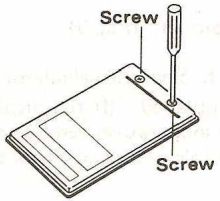


Fig. 1

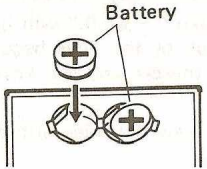


Fig. 2

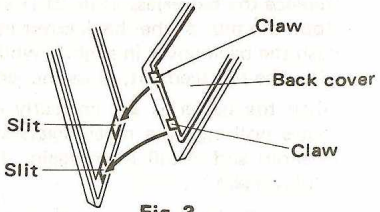


Fig. 3

YOUR OWN APPLICATION

YOUR OWN APPLICATION

SERVICE CENTER ADDRESS

SHARP ELECTRONICS CORPORATION
SHARP CONSUMER FACTORY SERVICE CENTER
430 East Plainfield Road
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Printed in Japan
1J5.9T(TINSE3369CCZZ)