This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

WARNING – FCC Regulations state that any unauthorized changes or modifications to this equipment not expressly approved by the manufacturer could void the user's authority to operate this equipment.

Note: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to Part 15 of the FCC Rules.
These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

**FOR YOUR RECORDS....**
For your assistance in reporting this Electronic Calculator in case of loss or theft, please record the model number and serial number which are located on the bottom of the unit.
Please retain this information.

Model Number _____ Serial Number _____

Date of Purchase_____ Place of Purchase _____

# Sharp EL-9200 and EL-9300 Graphing Scientific Calculators

## Owner's Manual and Solutions Handbook

## NOTICE

- The material in this manual is supplied without representation or warranty of any kind. SHARP Electronics Corporation assumes no responsibility and shall have no liability of any kind, consequential or otherwise, from the use of this material.
- SHARP strongly recommends that separate permanent written records be kept of all important data. Data may be lost or altered in virtually any electronic memory product under certain circumstances. Therefore, SHARP assumes no responsibility for data lost or otherwise rendered unusable whether as a result of improper use, repairs, defects, battery replacement, use after the specified battery life has expired, or any other cause.


### Special Thanks

Special thanks to Professor Iris Fetta, Professor John Kenelly, Professor Don LaTorre, and the rest of the Mathematical Sciences staff at Clemson University for their input and support throughout the development of the EL-9200 and EL-9300.






# Contents

# Congratulations!

The Sharp EL-9200 and EL-9300 Graphing Scientific Calculators continue in the Sharp tradition of providing the maximum computing power for your money. With a large number of functions and sophisticated graphing features, this calculator will assist you for many years to come.

Here are a few of the calculator's powerful features:

- **Graphs.** You can graph functions in rectangular or polar coordinates. You can also graph parametric equations.
- **Equation editor.** Calculations appear on the screen as they do on paper. The calculator remembers the last 110 keystrokes in calculation mode and you can go back and edit any of them (even after you've turned the calculator off and on again).
- **Statistics.** Entering statistics data is easy, and you can graph six different kinds of statistics graphs and six different regression curves.
- **Programs.** Your calculator is programmable, so you can automate and store common calculations. All the commands you need are in menus or on the keyboard.
- **Solver.** With the EL-9300's equation solver, you can solve advanced equations quickly and easily.
- **User-friendly interface.** You can select menu operations with the cursor keys or by keying-in letters and numbers.
- **Memory.** There is plenty of memory to store equations, programs, and statistics.
- **Built to last.** The calculator is ruggedly constructed and has a sliding front cover to protect your investment.



# About this manual

This section describes the contents of this manual, the notational conventions used in the text, and how to use this manual effectively.

## Chapter overview

This manual contains the following chapters:

- Chapter 1 – *A Quick Tour* explains the calculator's keys, the display, the menu system, and the operating modes.
- Chapter 2 – *General Information* explains how to set up the operating environment, and how to use the option menu.
- Chapter 3 – *Using the Calculator* explains how to use the calculator in normal operating mode (calculation mode).
- Chapter 4 – *Graphing* explains the graphing functions.
- Chapter 5 – *Programming* explains how to program the calculator.
- Chapter 6 – *Using Statistics* explains the statistical functions.
- Chapter 7 – *Graphing Statistics* explains the statistical graph functions.
- Chapter 8 – *Solving Equations* explains the solver functions of the EL-9300.
- Chapter 9 – *Getting Results* shows how to solve different types of problems from various disciplines.

The appendices contain battery replacement information, a list of error messages, a command index, and general specification information.

## Conventions used in this manual

The following conventions are used throughout this manual:

The keys on the the calculator appear in a box: [2ndF]

Key operations appear as follows:

$x^{-1}$ D
[$x^2$] D is the hexadecimal number D (or the letter D, if pressing [ALPHA] is not required)

[ALPHA] D is the letter D

[2ndF] [$x^{-1}$] is $x^{-1}$

[$x^2$] is $x^2$

[MENU] [D] is menu selection D

Words or numbers displayed on the screen appear as follows: RAD

## How to use this manual

The Sharp EL-9200 and EL-9300 Owner's Handbook is both a reference book and a tutorial of how to solve some common problems.

For quick reference, use the table of contents in the front of the manual. Also provided is an alphabetical index.

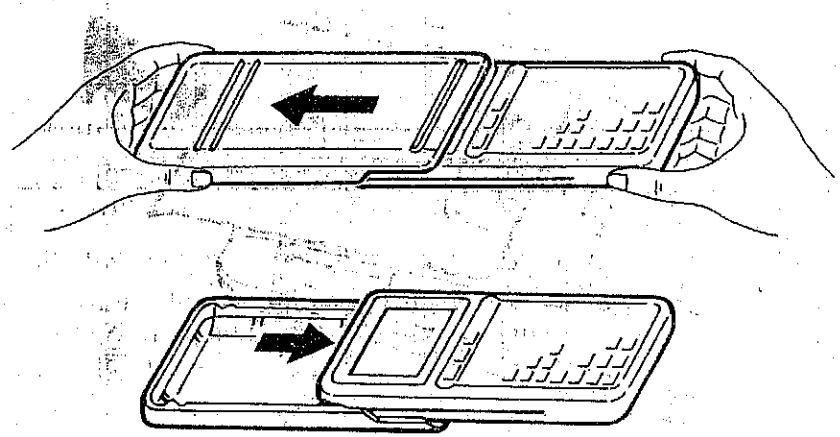
This manual is a straightforward step-by-step guide to using your calculator.



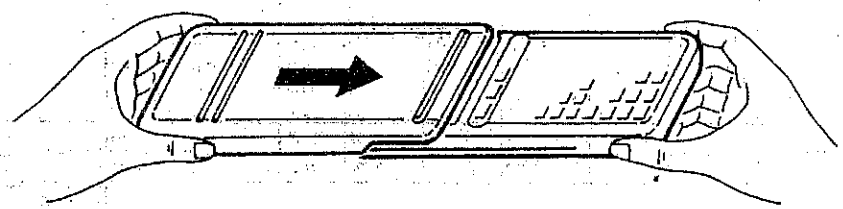
# The protective cover

Your calculator is supplied with a cover to protect the keyboard and display when the calculator is not in use.

Before using the calculator, remove the cover as shown.



When you are not using the calculator, slide the cover over the top of the calculator as shown.

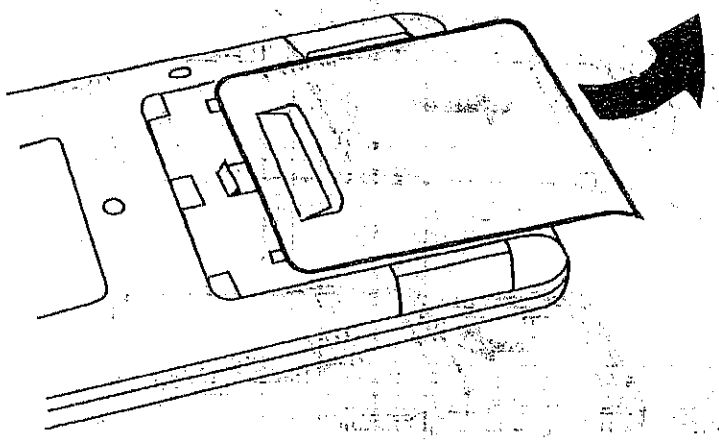


# The first time you use the calculator

The calculator uses four AAA batteries. Before using the calculator for the first time, you must install the batteries and reset the calculator.

Install the batteries as follows (for a detailed description of how to install the batteries, see Appendix A):

1. Slide off the battery compartment cover as shown.



2. Remove the battery plate by sliding it to the left.
3. Insert the batteries into the battery compartment (put the minus (-) ends in first against the springs). Make sure each battery is inserted in the correct direction, as shown on the inside of the compartment.
4. Replace the battery plate by sliding it back into its original position.
5. Replace the battery compartment cover.



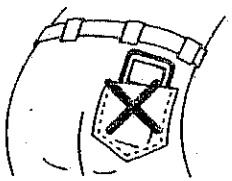
6. Use the tip of a ball-point pen to press the reset button on the back of the calculator. The reset button is near the upper right corner of the battery compartment. The following message appears:

```
PRESS [CL] TO
CLEAR ALL DATA

PRESS [ON] KEY
TO CANCEL
```

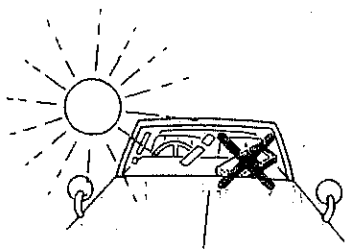
If you don't see this message, the batteries may have been inserted incorrectly; try again (repeat steps 1 through 6).

7. Press [CL] and then press any key.
   (this will erase any previous data if present)
8. Check that `REAL MODE` and `0.` are displayed.
9. Adjust the display contrast until you can see the display clearly. Press [2ndF] [OPTION] and press [+] or [-] until the contrast is set correctly, then press [QUIT].

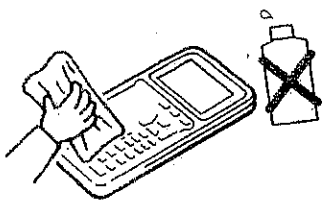
# Caring for your calculator



Do not carry the calculator around in your back pocket, as it may break when you sit down. The display is made of glass and is particularly vulnerable.

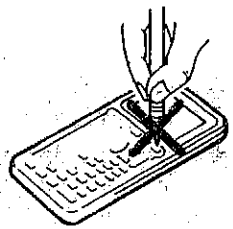


Keep the calculator away from extreme heat such as on a car dashboard or near a heater, and avoid exposing it to excessively humid or dusty environments.

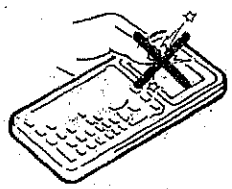


Clean with a soft, dry cloth using no solvents.





Do not use a sharp pointed object or exert too much force when pressing keys.

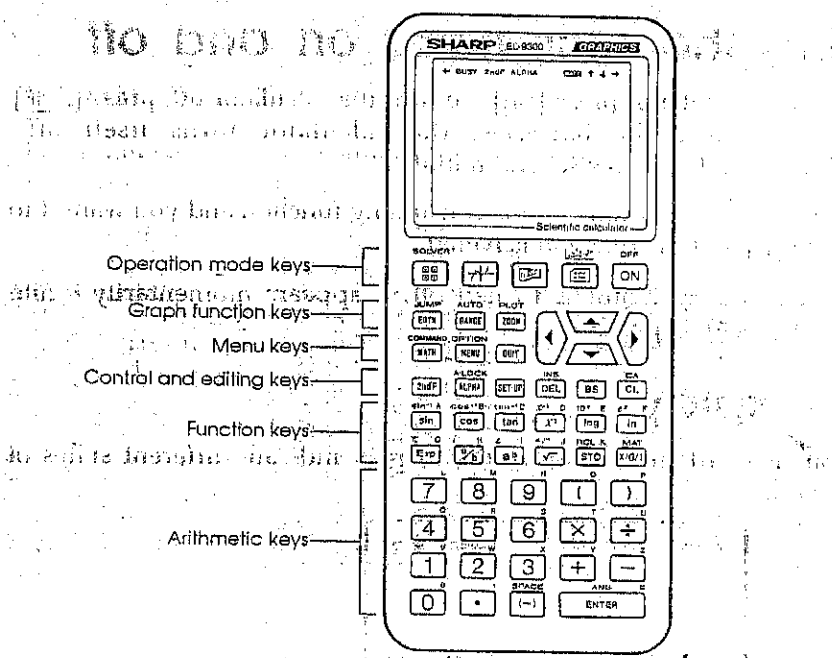


Avoid excessive physical stress.

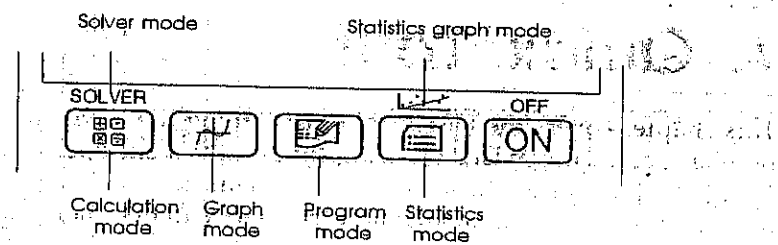
# CHAPTER 1:
# A Quick Tour

This chapter covers the basics, such as: turning the calculator on, entering numbers, correcting mistakes, using simple arithmetic operation keys, using [2ndF] and [ALPHA], and using the menu system. It also gives you an overview of each of the operating modes, and tells where to find more information.

## The keys of the calculator



The top row contains keys that determine the operation mode of the calculator:




Note: Solver mode is available only on the EL-9300.

# Turning the calculator on and off

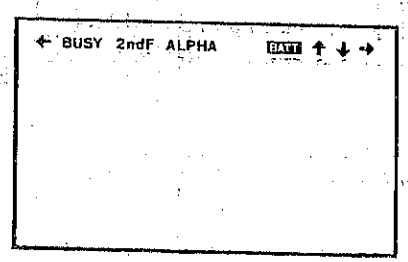
To turn on the calculator, press [ON]. To turn the calculator off, press [2ndF] [OFF]. To conserve the batteries, the calculator turns itself off automatically if not used for several minutes.

If the calculator is performing a time consuming function and you want it to stop, press [ON] and the function is halted.

Note: When the calculator is turned off, ↓ appears momentarily while [2ndF] [OFF] is pressed.

# The display

Several small words in the top of the display indicate different states of the calculator.




If the LOW indicator appears, the batteries need to be changed right away. In the EL-9300 there is a backup battery that retains the calculator's data





while you are changing the batteries. For a detailed description of how to change the batteries, see Appendix A.

# Getting a fresh start

The simplest mode to begin with is calculation mode (real). To operate in calculation mode press [▦]. Make sure the calculator is set to real mode, press [MENU] [1].

Note: Unless otherwise noted, all examples in this manual assume you are in floating point display format. This is the default display format. Changing the format is described in Chapter 2.

# Entering numbers

Enter numbers using the number keys [0] through [9], the decimal point key [.], and the change-sign key [(-)].

**Example:** Enter the number 123.4
Press: [1] [2] [3] [.] [4] [ENTER]
Result: 123.4

Note: Throughout the rest of this manual, numbers in examples are not shown in boxes.

## The enter key

[ENTER] tells the calculator to perform the operations entered in the display. The [2ndF] key allows you to select the second function of a key. Pressing [2ndF] [ANS] [ENTER] recalls the last result displayed.

| | |
|---|---|
| **Example:** | Divide 11 by 16 |
| Press: | 11 [÷] 16 [ENTER] |
| Result: | 0.6875 |

Now take the sine of the result:

| | |
|---|---|
| Press: | [sin] [2ndF] [ANS] [ENTER] |
| Result: | 0.63460708 (radians) |

## The change-sign key

The [(-)] key changes the sign of the number about to be entered in the display.

| | |
|---|---|
| **Example:** | Enter -38. |
| Press: | [(-)] 38 [ENTER] |
| Result: | -38. |

Note: The minus [-] key is not the same as [(-)]. Pressing any of the arithmetic keys before entering a number operates on the last displayed result.

## Using exponents

Your calculator displays up to 10 digits in its result display; however, it always retains 14 digits in memory. Numbers that cannot be represented with 10 digits are displayed in scientific notation.

In scientific notation, numbers are represented as a mantissa and an exponent. For example, the number 39250 is written in scientific notation as $3.925 \times 10^4$; 3.925 is the mantissa and 4 is the exponent.

Enter numbers using exponents as follows:

- Enter the mantissa. If the mantissa is negative, press [(-)] *before* entering the mantissa.





- Press the exponent key [Exp] and enter the exponent. If the exponent is negative, press [(-)] *before* entering the exponent.

| | |
|---|---|
| **Example:** | Enter $4.535 \times 10^{-17}$. |
| Press: | 4.535 [Exp] [(-)] 17 [ENTER] |
| Result: | 4.535E-17 |

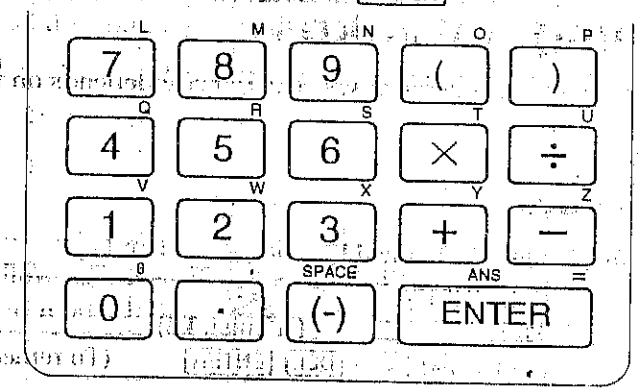
If you make a mistake while entering the exponent, simply backspace with [BS] (or [◄]) and enter the correct number.

| | | |
|---|---|---|
| **Example:** | Enter $7.4 \times 10^{12}$ | |
| Press: | 7.04 [Exp] 13 | Oops! Wrong exponent. |
| Press: | [BS] 2 [ENTER] | 12 replaces 13. |
| Result: | 7.04E 12 | Uh-oh. Mantissa is wrong too. |
| Press: | [2ndF] [▲] [◄] [◄] [◄] [◄] [◄] [DEL] [ENTER] | |
| Result: | 7.4E 12 | |

Note: [BS] deletes characters as it backs up, [◄] does not.

# Simple arithmetic

Simple calculations use the arithmetic operation keys ([+] [-] [×] [÷]), the parenthesis keys, the number keys, and [ENTER].



Simple calculations are entered from left to right as they appear on the written page.

**Example:** 5 + 3 x 4 x 2
Press: 5 [+] 3 [x] 4 [x] 2 [ENTER]
Result: 29.

The calculator performs multiplication before addition to arrive at the above result. Arithmetic precedence is described at the beginning of Chapter 2.

Decimals (for example 981.8) are entered just as they appear on the written page using [.]. Common fractions are entered using [a b/c] or [%].

**Example:** $981.8 \times \frac{4}{5}$

Press: 9 8 1 [.] 8 [x] 4 [%] 5 [ENTER]
or 9 8 1 [.] 8 [x] 4 [÷] 5 [ENTER]
Result: 785.44

Fractional results can be displayed three different ways. See *"Answers"* in Chapter 2 for more details.

# Correcting mistakes

Mistakes are remedied in several ways. The remedy depends on the type of mistake.

## The cursor keys

Incorrect keystrokes may be changed by using the cursor keys.

**Example:** Enter 345174
Press: 342174 (A mistake)
Press: [◄] [◄] [◄] [◄] 5 [DEL] [ENTER] (To remedy)

Pressing [DEL] is not required while in overtype mode. For more details, see *"Editing"* in Chapter 2.





The cursor keys perform the following functions:

| | |
|---|---|
| [▲] | Move up one line. |
| [2ndF] [▲] | Move to a previous equation (if any).[1] If within a menu, the cursor moves to the top of the menu. |
| [▼] | Move down one line. |
| [2ndF] [▼] | Move to the next equation (if any). If within a menu, the cursor moves to the bottom of the menu. |
| [◄] | Move one space to the left. |
| [2ndF] [◄] | Move to the start of an equation. |
| [►] | Move one space to the right. |
| [2ndF] [►] | Move to the end of an equation. |

Use [◄], [►], [▼], and [▲] to edit within equations. The cursor changes shape depending on its location within an equation. Normally the cursor is an underline (_). When the cursor is a vertical bar or block, it is within a function or equation. Move out of a function with [◄] or [►].

You can use the cursor keys to edit equations after you've pressed [ENTER] while the answer is still in the display. After you've entered another equation, you must use [2ndF] [▲] to edit a earlier equation. You can move up and down through the equations you've entered with [2ndF] [▲] and [2ndF] [▼].

---

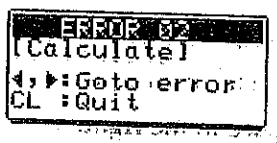
[1] The following keystrokes are remembered (and can be edited) while in calculation mode. If you change modes, the keystrokes are removed from memory.

| | EL-9300 | EL-9200 |
|---|---|---|
| In one line | 160 | 128 |
| In equation editor | 114 | 91 |

# Clearing errors

Syntax errors in equations and results that are too large to display or are not defined produce errors.

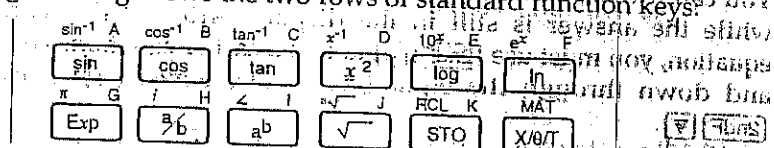
**Example:** 5 ÷ 0
Press: 5 [÷] 0 [ENTER]
Result:




Pressing [◀] or [▶] moves the cursor to the error. Pressing [CL] clears the error.

# Function keys

The following drawing shows the two rows of standard function keys:




In general, enter functions as if you were writing them on paper.

**Example:** log(37²)
Press: [log] 37 [x²] [ENTER]
Result: 3.136403448

The order of operation is described in Chapter 2.





# Storing to memory

You can store and recall numbers in 27 different memories (A-Z and θ). You don't have to press [ALPHA] after pressing the [STO]: alpha mode is entered automatically, and the ALPHA indicator appears on the display.

**Example:** Store 123 to memory Z
Press: 123 [STO] Z

Press [2ndF] [RCL] *letter* to recall a number stored in memory. You do not need to press [ALPHA] before pressing the letter, and the ALPHA indicator appears on the display.

**Example:** Recall Z
Press: [2ndF] [RCL] Z
Result: 123.

You can use the stored number without using [2ndF] [RCL].

**Example:** Multiply Z by 3
Press: 3 [ALPHA] Z [ENTER]
Result: 369.

# The variable key [X/θ/T]

The variable key [X/θ/T] lets you enter a capital X, θ, or T. The variable entered depends on the coordinate system selected ([SETUP] [E] choose rectangular [X], polar[θ], or parametric [T]). The default mode is rectangular, so [X/θ/T] enters an X.

# Second functions, alpha functions, and menu functions

The normal function of a key is printed on the cap of the key. Many of the keys also have second functions and alpha functions.

## Using [2ndF]

A function printed above a key in yellow is the second function of that key. Press [2ndF] before you press a key to use its second function. When you press [2ndF], the 2ndF indicator appears at the top of the display. If you press [2ndF] by mistake, simply press [2ndF] again and the indicator disappears.

**Example:** Compute $\sin^{-1}(1)$
(Notice that [sin⁻¹] is the second function of [sin].)
Press: [SET UP] [B] [1] [ENTER] selects degrees
[2ndF] [sin⁻¹] 1 [ENTER]
Result: 90. (degrees)

## Using [ALPHA]

A character printed above a key in blue is the alpha function of that key. Press [ALPHA] before you press a key to use its alpha function.

After you press [ALPHA], the ALPHA indicator appears in the top of the display to remind you that the next key you press enters its alpha function. If you press [ALPHA] by mistake, simply press [ALPHA] again and the indicator disappears. Pressing [2ndF] [A-LOCK] locks the calculator in alpha mode until [ALPHA] is pressed.

**Example:** Enter the letter A.
(Notice that [A] is the alpha function of [sin].)
Press: [ALPHA] A
Result: A





## The math key

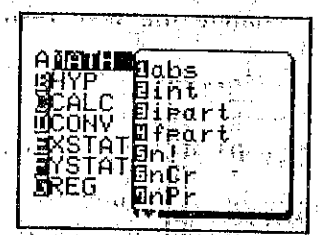
Each mode of the calculator has functions assigned to [MATH]. When you can't find a math function you want on the keyboard, press [MATH], and math functions available in the selected mode appear.

Use the cursor keys to select different menu headings, or press the letter that precedes the heading. Use the cursor keys and press [ENTER] to select a function in a submenu, or key-in the number that precedes the function you want.

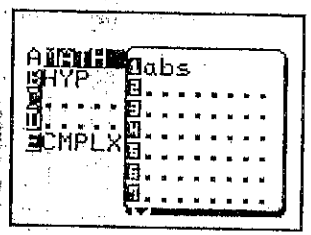
Note: It isn't necessary to press [ALPHA] before pressing a letter that selects a menu heading.

The available functions in the [MATH] menu depend on what mode you are using. For example:

In real mode [MENU] [1] [MATH]:




In complex mode [MENU] [4] [MATH]:

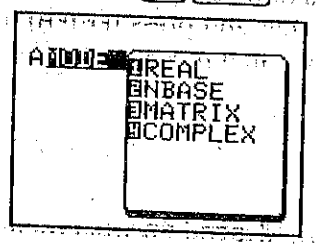



Functions that are not available are shown as dotted lines.

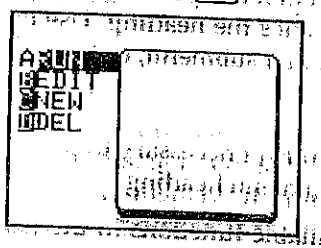
## The menu key

In general, when [MENU] is pressed, operations for the current mode appear. The operations that appear depend on what mode you are using. For example:

In calculation mode [▦] [MENU]:

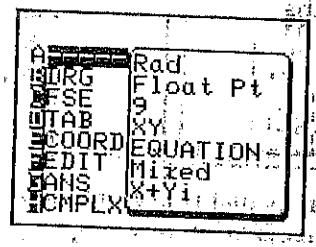



In programming mode [▤]:




## The set up key

Pressing [SET UP] displays settings that change the way results are calculated or displayed.




The current settings are displayed on the right. Options [B] through [H] let you change the angular units, the display format, the number of decimal points, the graphing coordinate system, screen editing mode, how fractional answers are displayed, and complex coordinates. For more information, see Chapter 2.





# Operating modes

The EL-9200 has five operating modes: calculation mode, graph mode, program mode, statistics mode, and statistics graph mode. The EL-9300 has a sixth mode: solver mode.

Use the operation mode keys ([▦] [📈] [▤] [▥] [2ndF] [📊] [2ndF] [SOLVER]) to enter a mode. Anytime you want to go to a specific mode, press the corresponding mode key and the calculator immediately enters that mode.

## Calculation mode [▦]

In calculation mode, you have a full range of mathematical functions and features.

**Example:** Evaluate the following definite integral: $\int_1^3 \sqrt{x^2-1}\,dx$

Press: [▦] [SET UP] [E] [1] [ENTER] [MATH] [C] [2]
1 [▲] 3 [▶] [√] [X/θ/T] [x²] [-] 1 [▶] [MATH] [3] [ENTER]

Result: 3.360942644

Note: When you select functions from the same menu it is not necessary to press the menu letter again.

**Example:** Convert 123 to hexadecimal.
Press: [MENU] [2] [MATH] [D] [2]
1 2 3 [MATH] [1]
Result: 000000007B

Calculation mode is described in the Chapter 3, *"Using the Calculator."*

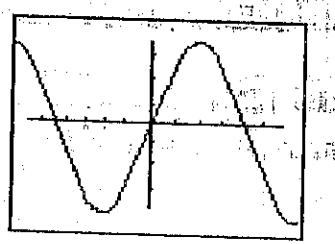
## Graph mode [A]

Graph mode lets you graph many functions using rectangular, polar, or parametric coordinates.

**Example:** Graph the function y=sin x

Press: [A] [SET UP] [B] [2] [ENTER]
[RANGE] [MENU] [ENTER] [QUIT]
[sin] [X/θ/T] [2ndF] [AUTO]

Result:



Graph mode is described in Chapter 4, *"Graphing."*

## Program mode [PRGM]

Program mode lets you write programs on your calculator.

**Example:** Write a program that asks you to enter X and Y coordinates, converts them to polar coordinates, and then displays them on the screen.

Press: [PRGM] C [ENTER] 1
POLAR [ALPHA] [ENTER]
[2ndF] [COMMAND] [A] [3] [X/θ/T] [ENTER]
[2ndF] [COMMAND] [A] [3] [ALPHA] [2ndF] Y [ENTER]
[2ndF] [A-LOCK] [2ndF] X [,] [2ndF] Y [ALPHA]
[MATH] [D] [3] [ENTER]
[2ndF] [COMMAND] [A] [1] [ALPHA] [2ndF] R [ENTER]
[2ndF] [COMMAND] [A] [1] [ALPHA] θ [ENTER]
[2ndF] [COMMAND] [A] [6] [ENTER]





The finished program should look exactly like this:

```
Polar
                    REAL
Input X
Input Y
X,Y→rθ
Print R
Print θ
End
```

To run the program press [MENU] A, select the program with the cursor keys and press [ENTER], or key-in the number that precedes the program.

**Example:** Use the above program to convert 3,4 to polar coordinates.

Press: [SET UP] [B] [1] [ENTER] [MENU] [A]
[ENTER] [ENTER] (Select the program)
3 [ENTER] 4 [ENTER]

Result: 5.
53.13010235

Program mode is described in Chapter 5, *"Programming."*

## Statistics mode [STAT]

Statistics mode lets you enter data for one- or two-variable statistics with (or without) weight. Data can be masked, sorted, stored to a matrix, or recalled from a matrix.

**Example:** Find the mean of the following five 100-meter dash track times: 10.3, 8.9, 9.9, 11.2, 11.0.

Note: If you have already entered statistics data, you must delete it (Press [STAT] [MENU] [D] [2] [ENTER]) before entering the following commands.

Press: [STAT] 1
10.3 [ENTER] 8.9 [ENTER] 9.9 [ENTER] 11.2 [ENTER] 11 [ENTER]
[MENU] A 1

Result:
```
x̄  =          10.26
sx = 0.923579991
σx = 0.826075057
Σx =          51.3
Σx²=        529.75
n  =             5.
xmi=             8.9
xma=            11.2
```

Statistics mode is described in Chapter 6, *"Using Statistics."*





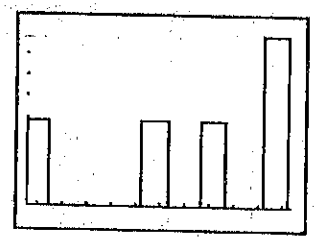
## Statistics graph mode [GRAPH]

Statistics graph mode lets you graph data entered in statistic mode. There are twelve types of graphs: six kinds of data graphs, and six kinds of regression curves.

**Example:** Display a histogram of the track time data from the previous example.

Press: [2ndF] [GRAPH] [A] [2ndF] [AUTO]

Result:



Statistics graph mode is described in Chapter 7, *"Graphing Statistics."*

## Solver mode (EL-9300 only) [SOLVER]

Solver mode provides three methods to solve for different variables in equations.

**Example:** Solve the for w: s=(1/z)*h*w

Press: [2ndF] [SOLVER] [ALPHA] S [ALPHA] = 1 [%] [ALPHA] Z
[▶] [X] [ALPHA] H [X] [ALPHA] W [ENTER]
6 [ENTER] 3 [ENTER] 4.5 [ENTER] [ENTER] [ENTER]

Result: w=4.

Solver mode is described in Chapter 8, *"Solving Equations."*

# CHAPTER 2:
# General Information

This chapter describes features that affect all modes of the calculator. It covers arithmetic precedence, setup features, and the option menu.

## Precedence

The calculator always performs calculations in the proper arithmetic order, which may not be the order you entered them.

If you don't use parentheses to specify the order of calculation, the calculator uses the following precedence:

| PRECEDENCE | OPERATION |
|---|---|
| Highest | Operations in fractions |
| | Complex angle calculations ($\theta$ in $r\angle\theta$) |
| | Functions that follow an entry (for example, n!, $x^2$, $x^{-1}$) |
| | The first part of $a^b$ |
| | Implied multiplication with $\pi$ or a variable (for example, $4\pi$, 6X) |
| | Functions that precede an entry (for example, sin, log) |
| | Implied multiplication with a function (for example, 5 sin, 2 ln) |
| | *n*Pr, *n*Cr |
| | ×, ÷ |
| | +, – |
| | AND |
| | OR, XOR, XNOR |
| | $\rightarrow xy$, $\rightarrow r\theta$ |
| Lowest | ⇒ (storing to memory), = |

High precedence operations are performed before low precedence operations. Operations of the same precedence are performed in the order they are entered. Operations within parenthesis are always performed first.

**Example:** 9+5 x 4
Is calculated in the following order:
5 x 4 is multiplied first, then 9 is added to the product.
Press: [ON/OFF] [MENU] [1] (Enter real calculation mode.)
9 [+] 5 [x] 4 [ENTER]
Result: 29.

**Example:** 5 + 6 x log 100
Is calculated in the following order:
The log of 100 is multiplied by 6 and 5 is added to the product.
Press: 5 [+] 6 [x] [log] 100 [ENTER]
Result: 17.

## Parentheses

You may specify the calculation precedence by using the parentheses ([(] and [)]). Parentheses are entered as they would appear in a written equation. Expressions within parentheses are always computed first.

**Example:** (9 + 4) x 5
Press: [(] 9 [+] 4 [)] [x] 5 [ENTER]
Result: 65.

Once you press [(], parentheses are considered open until closed by pressing [)] or [ENTER].

Parentheses may be nested up to 32 levels deep. The calculator allows up to 32 pending operations and stores up to 14 numbers.

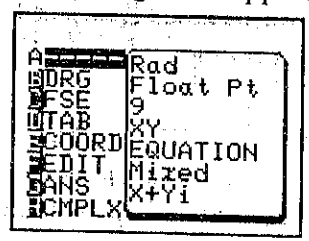




# The set up menu

The set up menu lets you change the angular mode, the display format, the graphing coordinate system, editing mode, the way fractional results are displayed, and the way complex numbers are displayed.

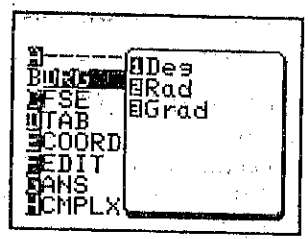
After pressing [SET UP] the following menu appears:




This displays the current settings of all of the set up options. The current setting for each option is shown to the right of the option heading.

## Degrees, radians, grads

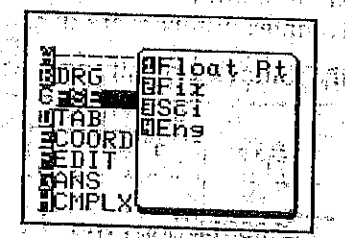
B DRG lets you select angular units (degrees, radians, or grads) for trigonometric functions. After pressing [SET UP] [B], the following menu appears:




Press 1, 2, or 3 to select degrees, radians, or grads, respectively. A circle is divided into 360 degrees, 2π radians, or 400 grads.

## Display formats

FSE (which stands for Fixed-Scientific-Engineering) lets you select one of four different display formats. When you press SET UP C the following menu appears:




Float Pt sets the display format to floating point which uses only the number of decimal places required to display a number. Up to 10 significant digits can be displayed.

Fix sets the display format to fixed point which displays numbers with a fixed amount of decimal places. Results are rounded off to the correct number of decimal places. (TAB sets the number of digits that follow the decimal point.)

Sci sets the display format to standard scientific notation. For example, the number 39256 would be written $3.9256 \times 10^4$ and displayed as 3.9256 E 4. The mantissa is displayed to the left of the letter E, and the exponent is displayed to the right of the letter E. (TAB sets the number of displayed decimal places in the mantissa.)

Eng sets the display format to engineering notation which is similar to scientific format except that the exponent is always a multiple of 3. The mantissa ranges from 1 to 1000 instead of 1 to 10. For example, the number 39256 would be displayed as 39.256 E 3. (TAB sets the number of displayed decimal places in the mantissa.)

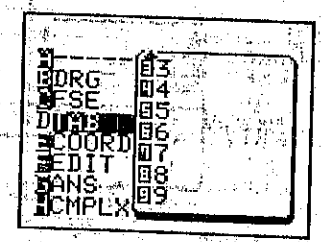
If a number is too large or too small to be displayed in a selected format, scientific notation is used.





## Decimal places

TAB changes the number of decimal places for fixed point, scientific notation, and engineering units. Press SET UP D and the following menu appears:




Use the cursor keys to highlight the desired number of decimal places (0-9) and press ENTER (or simply press 0-9).

TAB has no effect when FSE is set to Float Pt.

The number of decimal places affects the results from the modify command (mdf). For more information, see *"Conversions"* in the next chapter.

## Rounding

Frequently, the calculator must round a number to display it in the selected format. However, the calculator retains the more precise version of the number internally. This way the calculator minimizes most rounding errors.

**Example:** At a fixed display of 6-decimal places, divide 5 by 9.

Press: SET UP C 2 D 6 ENTER (Selects Fix, 6-decimal places)

5 ÷ 9 ENTER

Result: 0.555556

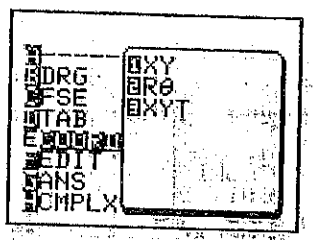
**Example:** Change the number of decimal places to 2.

Press: SET UP D 2 ENTER

Result: 0.56

## Coordinates

■COORD sets the coordinate type used for graphing. Press [SET UP] [E] and the following menu appears:



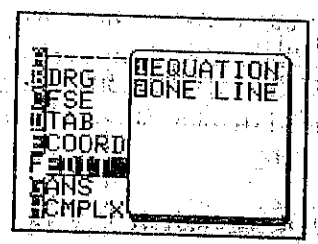

■XY selects rectangular coordinates.

■Rθ selects polar coordinates.

■XYT selects parametric equation mode.

## Editing

■EDIT sets the editing mode of the calculator. There are two editing modes; equation edit mode and one line edit mode. Press [SET UP] [F] and the following menu appears:








■EQUATION selects the equation edit mode (this is the default mode). Equations appear on the screen as they are commonly written on paper. This simplifies the entering and reading of equations. You must exit functions (use [▶]) that can operate on more than one number.

**Example:** Enter the square root of one-quarter cubed, times the absolute value of -15 in equation edit mode.

Press: [SET UP] [C] [1] [F] [1] [ENTER]
[√] 1 [%] 4 [▶] [a^b] 3 [▶] [▶] [X] [MATH] [A] 1 [(-)] 15 [ENTER]

The equation will look like this: $\sqrt{\left(\frac{1}{4}\right)^3} * |-15| = 1.875$

Equation edit mode is not available in program mode, nbase mode, or when entering values into fields such as the range screen, a statistics card, or a matrix element.

Equation edit mode always inserts characters when editing equations. To delete characters, press [DEL].

Note: The calculator's input response time is slower in equation edit mode. You can continue to enter keystrokes before they are displayed, but the input buffer has a four keystroke maximum.

■ONE LINE selects one line edit mode. Equations appear in a line as they would on a typical calculator. Equations with more than 16 characters wrap to the next line. Unlike equation edit mode, you do not need to use [▶] to exit functions.

**Example:** Enter the square root of one-quarter cubed, times the absolute value of -15 in one line edit mode.

Press: [SET UP] [F] [2] [ENTER]
[√] [(] 1 [%] 4 [)] [a^b] 3 [X] [MATH] 1 [(-)] 15 [ENTER]

The equation will look like this:

√(1┌4)^3* abs -15 = 1.875

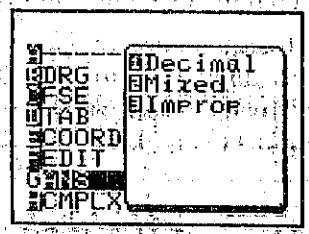
One line edit mode types over characters when editing equations. To insert characters, press [2ndF] [INS]. In overtype mode the cursor is a block: ■. In insert mode the cursor is a triangle: ◀.

When using [%], fractions are displayed a┌b.

The calculator's input response time is faster in one line edit mode.

## Answers

ANS selects the way fractional answers are displayed. Press [SET UP] [G] and the following menu appears:




1 Decimal sets the calculator to display fractional results in decimal form.

Example: $\frac{1}{5} * 11$

Press: [SET UP] [F] [1] [G] [1] [ENTER]
1 [a b/c] 5 [▶] [X] 11 [ENTER]

Result: 2.2

2 Mixed sets the calculator to display fractional results as mixed numbers.

Example: After doing the previous example, show the mixed result.

Press: [SET UP] [G] [2] [ENTER]

Result: $2\frac{1}{5}$

3 Improp sets the calculator to display fractional results as improper.

Example: After doing the above example, show the improper result.

Press: [SET UP] [G] [3] [ENTER]

Result: $\frac{11}{5}$

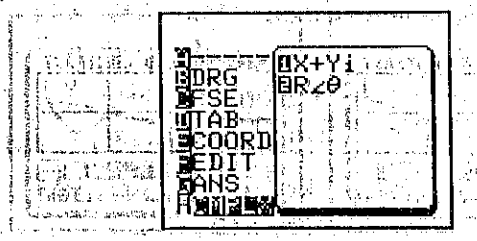
Fractions are displayed differently in one line edit mode.





## Complex coordinates

CMPLX sets the coordinate type used for display and conversion functions while in complex mode. Press [SET UP] [H] and the following menu appears:




1 X+Yi selects rectangular coordinates.

2 R∠θ selects polar coordinates.

To convert from one coordinate system to the other, select the coordinates you want to change to, enter the complex number, and press [ENTER]. The results obtained from these conversions are dependent on the angular mode.

Example: Change 45∠30 to rectangular coordinates.

Press: [MENU] [4] [SET UP] [B] [1] [C] [1] [H] [1] [ENTER]
45 [2ndF] [∠] 30 [ENTER]

Result: 38.971143+22.5*i*

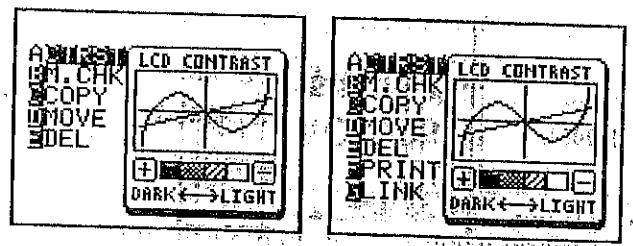
# The option menu

The option menu controls the following functions: display contrast, memory usage, copying and moving files, and deleting data.

EL-9300 only: The option menu also controls printing and linking to other devices.

## Contrast

To change the display contrast, press [2ndF] [OPTION] and one of following menus appears:




*The EL-9200 option menu* *The EL-9300 option menu*

Note: If you are in calculation, statistics, or statistics graph mode, the copy and move options will not be available.

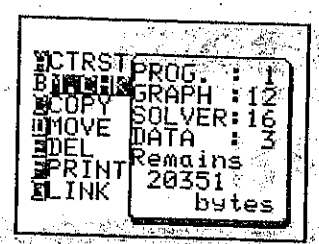
To darken the display contrast press [+].

To lighten the display contrast press [-].

Note: It is possible to lighten the display contrast until the calculator appears to be off. If the calculator display is blank when you press [ON], press [2ndF] [OPTION] and [+] (repeatedly) to darken the display contrast.

## Memory check

M. CHK shows you how much memory is being used for storage, and counts how many programs, graph files, solver files (EL-9300 only), and matrices are stored. Press [2ndF] [OPTION] [B] and a menu similar to the following appears:








PROG shows the number of stored programs.

GRAPH shows the number of stored graph files.

SOLVER shows the number of stored solver files.

DATA shows the number of stored matrices. If statistics data has been entered, DATA is incremented by 1.

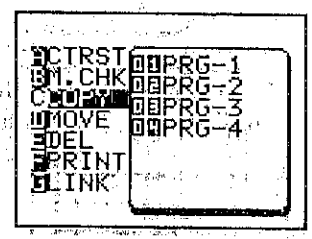
The EL-9200 has approximately 1.8 kilobytes of available memory.[2]

The EL-9300 has 23 kilobytes of available memory.

For a detailed description of how memory is used, see Appendix D.

## Copying files

COPY copies files. Press [2ndF] [OPTION] [C] and a menu similar to the following appears (if you have not created any programs the submenu will appear blank):



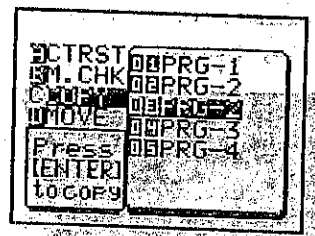

[2] Available memory is the memory not being used by the calculator to store settings, memories, etc.

To copy a file, you must be in the mode that contains the file that you want to copy (for example, you must be in program mode to copy a program).

Example: Assuming you have a list of programs stored, copy program 02.

Press: [▶M] [2ndF] [OPTION] [C] 02

The display shows:



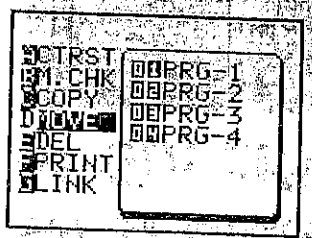

Use [▼] and [▲] to position the file within the list.

Press: [ENTER]

Result: The file is copied.

## Moving files

MOVE repositions a file in a list without making a copy. Press [2ndF] [OPTION] [D] and a menu similar to the following appears:





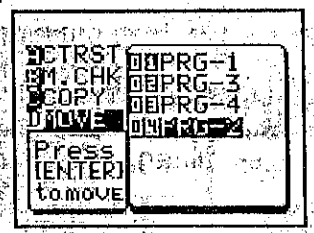



To move a file, you must be in the mode that contains the file you want to move (for example, you must be in program mode to move a program).

Example: Move program 02 to be program 04.

Press: [▶M] [2ndF] [OPTION] [D] 02 [▼] [▼]

The display shows:

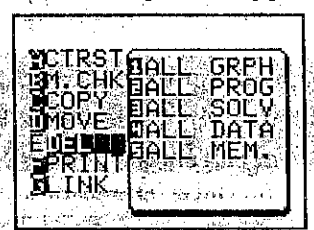



Press: [ENTER]

Result: The file is moved.

## Deleting files

DEL deletes all files from a particular mode or clears all memory. Press [2ndF] [OPTION] [E] and the following menu appears:




ALL GRPH deletes all graph files.

ALL PROG deletes all program files.

ALL SOLV deletes all solver files (EL-9300 only).

ALL DATA deletes all the data stored in matrices and statistics cards.

ALL MEM. deletes all files and all data.

Note: Once a file has been deleted there is no way to recover it, unless it is backed up on another device.

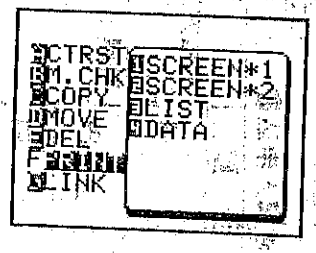
To delete individual files, enter the mode that contains the files you want to delete, and use the mode specific delete function (found in the MENU menu).

## Printing

(EL-9300 only)

If your EL-9300 is connected to the SHARP CE-50P Printer, PRINT prints the current screen two different ways. You can also list a program, print a stored equation, print all of the data in a matrix, or print the statistics registers.

Press 2ndF OPTION F and a menu similar to the following appears:




Note: In graph, solver, and program mode, DATA is not available. In calculation and statistics mode, LIST is not available.

SCREEN*1 prints the current screen of the selected mode on the SHARP CE-50P Printer and Cassette Interface. The print area is 96 dots wide by 64 dots high.

SCREEN*2 prints the current screen of the selected mode *sideways* on the SHARP CE-50P Printer and Cassette Interface. The print size is twice that of SCREEN *1. Equations that normally scroll off the screen are printed in full.





LIST lets you select a file from a list for printing. To print a file, you must be in the mode that contains the file you want to print (for example, you must be in program mode to print a program). Solver and graph files written in equation edit mode print in SCREEN*2 format at normal size.

Example: Print program 02 (assuming you have two programs).
Press: ▷ 2ndF OPTION F 3 02
Result: The program is printed.

DATA prints the data stored in a matrix or in stored statistics registers. You must be in calculation mode to print a matrix or in statistics mode to print statistics data.

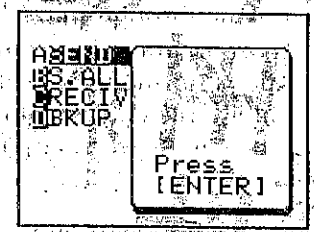
Note: If you want to print the set up menu, press SET UP 2ndF OPTION. You may have problems printing reverse text, or filled graphs while using the AC adapter (EA-23E) for the SHARP CE-50P. Use batteries in CE-50P, and disconnect the AC adapter.

If an error occurs during printing, ERROR 70 I/O device appears.

## Linking to other devices

(EL-9300 only)

LINK lets you transfer files and data between two calculators (EL-9300), or between a calculator and a cassette tape. Press 2ndF OPTION G ENTER and a menu similar to the following appears:




SEND sends a particular file or matrix from one calculator to another. You must have a transfer cable (SHARP CE-300L) that plugs into the bottom of each calculator. (Pry open the small plastic cover.) Both calculators must be in the same mode. You can transfer data in either direction, but during each transfer one calculator must send and the other must receive.

When you transfer data in statistics mode, press [≡] on the receiving calculator immediately after transfer.

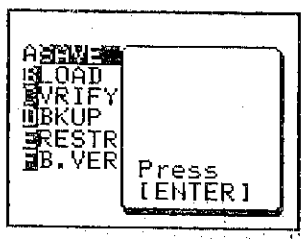
In statistics mode no file or data selection is required, simply select SEND and all of the statistic cards are sent.

S.ALL sends the entire stored contents of the current mode. The receiving calculator's memory for the selected mode will be replaced with the sending calculator's memory. A warning message is displayed. Press [ENTER] to continue with the transfer, press [CL] to quit.

RECIV receives files from another calculator. The order that send and receive are pressed does not matter.

BKUP copies all files, statistics, and matrices to another calculator. Both calculators must be in the same mode. The receiving calculator's memory will be replaced with the sending calculator's memory. A warning message is displayed before the receiving calculator's memory is cleared. Press [ENTER] to continue with the transfer, press [CL] to quit.

If you are connected to the CE-50P and switched on when LINK is selected, the following menu appears:




SAVE sends all files or data (depending on what mode you are in) from your calculator to a cassette tape through the SHARP CE-50P Printer and Cassette Interface. For the most accurate data transfer, use the AC adapter (EA-23E) for the CE-50P while performing calculator to tape transfers. The calculator prompts you to enter a file name (eight characters or less). Press record and play on the cassette before pressing [ENTER]. If the remote cable is used, the cassette will start automatically.

LOAD retrieves files or data from a cassette tape. You must be in the correct mode to retrieve files. (For example, you must be in program mode to retrieve program files.) The calculator's memory will be replaced with the information retrieved from the cassette tape. A warning message is displayed. Press [ENTER] to continue with the transfer, press [CL] to quit.





Note: When restoring from a tape, you must wind the tape to the location of the data and press play. If the remote cable is connected, the tape will start and stop automatically. If you are not using the remote cable, you must start and stop the cassette manually. Be patient, tape transfers may take over 15 minutes. Remember where you stored the data on the cassette tape.

VRIFY verifies that a file was correctly transferred to the cassette tape.

BKUP lets you copy all memories from all modes to a cassette tape.

RESTR restores a back up session from a cassette tape. The calculator's memory will be replaced with the information retrieved from the cassette tape. A warning message is displayed. Press [ENTER] to continue with the transfer; press [CL] to quit.

B.VER verifies that the back up session was transferred correctly to the tape.

**Example:** Save, verify and then load all of your program files.
First, connect the CE-50P and turn it on.
Connect the cables to the cassette player:
EAR to Earphone
MIC to Microphone
REM to Remote
Make sure the remote switch on the CE-50P is on.
Reset the counter on the cassette, and insert a tape.

Press: [≡] [2ndF] [OPTION] [G] [ENTER] [ENTER] p r o g r a m s
Press record and play on the cassette.

Press: [ALPHA] [ENTER]
When the transfer is complete, the program menu is displayed.

Write the start and stop counter numbers and the file name (programs) on the cassette tape.

Now, verify that the transfer was successful.
Rewind the cassette slightly in front of the stored programs.

Press: [≡] [2ndF] [OPTION] [G] [ENTER] [C] [ENTER] p r o g r a m s
Press play on the cassette.

Press: [ALPHA] [ENTER]

After a few seconds, the calculator will confirm that it has located the program. If the verify is successful, the program menu is displayed. If not, Error 72 appears.

Finally, load the stored files from the tape.

Rewind the cassette slightly in front of the stored programs.

Press: [2nd F] [OPTION] [G] [ENTER] [B] [ENTER] [ENTER] (To confirm deletion of old programs.)

p r o g r a m s

Press play on the cassette.

Press: [ALPHA] [ENTER]

After a few seconds, the calculator will confirm that it has located the program. If the load is successful, the program menu is displayed.

## Cassette troubleshooting

If you are having problems with the cassette, check the following:

Make sure the CE-50P is:

on

connected to the calculator

Switched to remote

powered by fresh batteries or the AC adapter

EAR is connected to the earphone on the cassette

MIC is connected to the microphone on the cassette (you may have to disconnect this during verify and load)

REM is connected to the remote on the cassette

Make sure the cassette's:

volume is set to the 3/4 max

tone is set to the middle

If everything is set up correctly, check if the cassette is wound to the correct spot: press play and listen for a high-pitched sound like a fax signal.





Wind the tape to the correct position. If it still does not work, try a different tape or a different player.

If you are trying to verify data, and you get an error, make sure that no program or matrices were added or changed since you saved the files.

If the calculator can't find the name your looking for, make sure you have the correct name.

Make sure the calculator is in the correct mode, for example, you must be in program mode to receive programs.

Make sure there is enough room on the tape for the files.

# Using memories

Your calculator has 27 memories for storage of results of calculations. The memories are identified as A-Z and θ.

The number in the display is copied to memory by pressing [STO] and a letter.

Note: Do not press [ALPHA] before selecting a letter for storing or recalling numbers. Pressing [STO] or [RCL] automatically activates the alpha feature. *An easy way to recall the contents of a memory is by keying-in the letter and pressing* [ENTER].

Memories can be accessed in all modes of the calculator and are retained when the power is turned off.

| | |
|---|---|
| **Example:** | Store 5 in memory C and store 24 in memory Z. |
| Press: | 5 [STO] C 24 [STO] Z |
| Verify by: | [2ndF] [RCL] C |
| Result: | 5. |
| Press: | [ALPHA] Z [ENTER] |
| Result: | 24. |

You can use memory locations in equations.

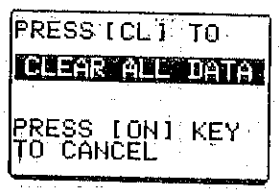
| | |
|---|---|
| **Example:** | Multiply Z by 4. |
| Press: | 4 [ALPHA] Z [ENTER] |
| Result: | 96. |

There is one more memory, Ans. Ans always stores the answer from the last calculation. Recall Ans by pressing [2ndF] [ANS] [ENTER].

## Resetting the calculator

If this calculator is subjected to strong external noise or shock during use, a rare condition may occur in which all keys, including the [ON] key, do not function. In this case, press the reset switch.

To reset the calculator, press the reset button located on the back of the calculator near the upper right corner of the battery compartment. The following message appears:




If you press [CL], all of the data in the calculator and all memories are erased.

If you press [ON] the reset operation is cancelled.



# CHAPTER 3: Using the Calculator

This chapter introduces some of the advanced features of your Sharp calculator. It covers the different calculation modes, function keys, and menu functions.

## Calculation modes

Calculation mode has four submodes of operation. Change modes by pressing [MENU] and selecting a new mode. The modes are as follows:

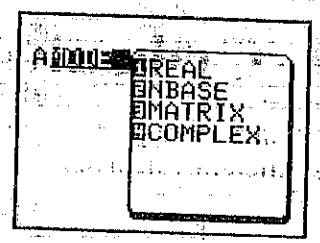
- **Real** Normal operating mode. You can perform calculations using real numbers in this mode.
- **Nbase** Binary, octal, decimal, or hexadecimal operating mode. You can perform base conversions and logical operations in this mode.
- **Matrix** Matrix operating mode. You can enter matrices and perform matrix operations in this mode.
- **Complex** Complex operating mode. You can enter complex numbers and perform calculations using complex numbers in this mode.

The calculator stays in the selected mode after the power is turned off.

## Real mode

Real mode is used for standard calculations. Real mode has the widest variety of available functions. However, many of the functions described in this section can be used in other modes.

While in calculation mode, press [MENU] [A] and the following menu appears:




Enter real mode by pressing 1, or use the cursor keys and press [ENTER].

## Fractions

You can work with fractions directly, without converting them to decimal form. You can perform calculations using decimal, mixed, or improper fractions.

### Entering fractions

Enter common fractions using [a b/c] as follows:

1. Enter the numerator.
2. Press [a b/c].
3. Enter the denominator.

If you make a mistake while entering the fraction, you can correct it with [◄] or [BS] (even after you've pressed [ENTER]).

**Example:** Enter the fraction $\frac{367}{465}$

Press: [SET UP] [F] [1] [G] [2] [ENTER] 367 [a b/c] 465 [ENTER]

Result: $\frac{367}{465}$

**Example:** Enter the mixed fraction $5\frac{2}{3}$

Press: 5 [+] 2 [a b/c] 3 [ENTER]

Result: $5\frac{2}{3}$





### Converting fractions

You can convert between decimal, mixed and improper fractions by using [SET UP] and [ENTER]. See the section called *"Answers"* in Chapter 2 for more information.

**Example:** Enter $398\frac{4}{10}$ as a mixed fraction then convert to it to decimal.

Press: [SET UP] [G] [1] [ENTER]
398 [+] 4 [a b/c] 10 [ENTER]

Result: 398.4

Now convert it to an improper fraction:

Press: [SET UP] [G] [3] [ENTER]

Result: $\frac{1992}{5}$

Return to decimal mode: [SET UP] [G] [1] [ENTER].

## Pi

Pressing [2ndF] [π] enters pi into the display. Only the first ten digits are displayed if you press [ENTER], but the calculator uses fourteen digits in calculations.

**Example:** Enter π.

Press: [2ndF] [π] [ENTER]

Result: 3.141592654

If you want to see the rest of the digits, subtract 3.141 from π and multiply the result by 10,000 (or change the display format to scientific notation).

## The trigonometric functions

You can calculate trigonometric functions (and their inverses) of angles measured in degrees, radians, or grads.

A circle has 360°, 2π radians, or 400 grads.

## Selecting angular units

To select degrees, radians, or grads, press [SET UP]. The angular unit selected is displayed at the top of the list on the right. Change it by pressing B and the number that precedes the desired angular unit.

## Sines, cosines, and tangents

The [sin], [cos], and [tan] keys calculate the sine, cosine, and tangent of a number. When using these keys, be sure the calculator is set for the angular unit you want.

**Example:** Calculate sin 30°, cos $\frac{\pi}{2}$ radians, and tan 150 grads.

Press: [SET UP] [B] [1] [ENTER]
[sin] 30 [ENTER]
Result: 0.5
Press: [SET UP] [B] [2] [ENTER]
Press: [cos] [2ndF] [π] [%] 2 [ENTER]
Result: 0.
Press: [SET UP] [B] [3] [ENTER]
[tan] 150 [ENTER]
Result: –1.

The [2ndF] [sin⁻¹], [2ndF] [cos⁻¹], and [2ndF] [tan⁻¹] keys calculate the arcsine ($\sin^{-1}$), arccosine ($\cos^{-1}$), and arctangent ($\tan^{-1}$) of a number. The result is always the smallest (positive or negative) angle that has a sine, cosine, or tangent equal to the number operated on. For example, the sines of -210°, 30°, 150°, and 390° are all 0.5. The arcsine of 0.5 is 30°, the smallest angle whose sine is 0.5.

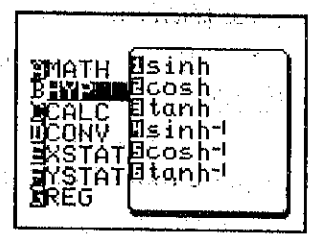
**Example:** Calculate $\sin^{-1}$ -1 in degrees.
Press: [SET UP] [B] [1] [ENTER] [2ndF] [sin⁻¹] [(-)] 1 [ENTER]
Result: -90.
**Example:** Calculate $2\cos^{-1}$ 0 in radians.
Press: [SET UP] [B] [2] [ENTER]
2 [2ndF] [cos⁻¹] 0 [ENTER]
Result: 3.141592654





## Hyperbolic sines, cosines, and tangents

Select hyperbolic trigonometric functions by pressing [MATH] [B]. The following menu appears:




Select the desired hyperbolic function by pressing the number to the left of the function.

**Example:** Find the hyperbolic cosine of 0.
Press: [MATH] [B] [2] 0 [ENTER]
Result: 1.

**Example:** Find the inverse hyperbolic sine of 7.544.
Press: [MATH] [B] [4] 7.544 [ENTER]
Result: 2.718263812

Your calculator has many functions that are selected from menus. See *"Math menu functions"* later in this chapter for a description of the other math menus.

# Power functions

You can perform standard power and root calculations with the [$x^2$], [$a^b$], [$\sqrt{}$], [2ndF] [$\sqrt[a]{}$], and [2ndF] [$x^{-1}$] keys.

The [$x^2$] key calculates the square of the number in the display.

**Example:** Calculate the square of 15.
Press: 15 [$x^2$] [ENTER]
Result: 225.

The [a^b] key raises $a$ to the power $b$. Use it as follows:

1. Enter the number that you want to raise to a power.
2. Press [a^b].
3. Enter the exponent, and press [ENTER].

| | |
|---|---|
| **Example:** | Calculate 7 to the 4th power ($7^4$). |
| Press: | 7 [a^b] 4 [ENTER] |
| Result: | 2401. |

The [√] key calculates the square root of the next number typed on the display.

| | |
|---|---|
| **Example:** | Calculate the square root of 27. |
| Press: | [√] 27 [ENTER] |
| Result: | 5.196152423 |

The [2ndF] [ˣ√] key calculates the $a^{th}$ root of the number. Use it as follows:

1. Enter the root.
2. Press [2ndF] [ˣ√].
3. Enter the number and press [ENTER].

| | |
|---|---|
| **Example:** | Find the fifth root of 243. |
| Press: | 5 [2ndF] [ˣ√] 243 [ENTER] |
| Result: | 3. |

The [2ndF] [x⁻¹] key calculates the inverse of the number in the display. This is the same as $\frac{1}{x}$.

| | |
|---|---|
| **Example:** | Calculate the inverse of 0.5. |
| Press: | 0.5 [2ndF] [x⁻¹] [ENTER] |
| Result: | 2. |

## Logarithms and exponentials

You can calculate common (base 10) and natural (base $e$) logarithms and exponentials (antilogarithms) using the [log], [ln], [2ndF] [10ˣ], and [2ndF] [eˣ] keys.





The common logarithm key [log] calculates the base 10 logarithm of a number.

| | |
|---|---|
| **Example:** | Calculate the common logarithm of 31.62. |
| Press: | [log] 31.62 [ENTER] |
| Result: | 1.499961866 |

The natural logarithm key [ln] calculates the base $e$ logarithm of a number.

| | |
|---|---|
| **Example:** | Calculate the natural logarithm of 31.62. |
| Press: | [ln] 31.62 [ENTER] |
| Result: | 3.453789832 |

The [2ndF] [10ˣ] key raises 10 to the power of a number.

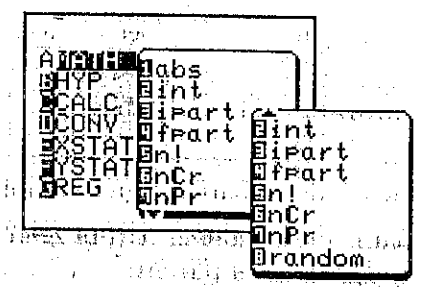
| | |
|---|---|
| **Example:** | Calculate $10^{4.7}$. |
| Press: | [2ndF] [10ˣ] 4.7 [ENTER] |
| Result: | 50118.72336 |

The [2ndF] [eˣ] key raises $e$ to the power of a number.

| | | |
|---|---|---|
| **Example:** | Calculate $e^1$. | |
| Press: | [2ndF] [eˣ] 1 [ENTER] | |
| Result: | 2.718281828 | This is the base number $e$. |

## Math menu functions

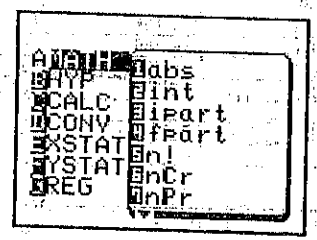
The [MATH] key displays a math function menu, and each mode has different menus. Some of the functions operate on numbers that appear either before or after the function. Some functions require more than one number, others simply recall values from statistical registers. In calculation mode, after pressing [MATH] [A] the following display appears:



Menu headings can be selected with the cursor keys or by keying-in the letter that precedes the heading (you do not have to press [ALPHA] first). Menu functions can be selected with the cursor keys or by keying-in the number that precedes the function. For example, to select n!, press 5, or press [▶] [▼] [▼] [▼] [▼] [ENTER].

## Absolute values, integers, factorials, combinations, permutations, and random numbers

Pressing [MATH] [A] displays the following:




**1** `abs` is the absolute value function. Absolute value can be defined as $\sqrt{x^2}$ for all real x.

**Example:** What is the absolute value of -7?
Press: [MATH] [A] [1] [(-)] 7 [ENTER]
Result: 7.

**2** `int` returns the greatest integer equal to or less than the given number.

**Example:** What is the integer value of -7.94?
Press: [MATH] [A] [2] [(-)] 7.94 [ENTER]
Result: -8.

**3** `ipart` returns only the integer part of a given number.

**Example:** What is the integer part of -7.94?
Press: [MATH] [A] [3] [(-)] 7.94 [ENTER]
Result: -7.

**4** `fPart` returns only the fractional part of a given number.

**Example:** What is the fractional part of 7.94?
Press: [MATH] [A] [4] 7.94 [ENTER]
Result: 0.94





**5** `n!` calculates the factorial of an integer in the display. A factorial is the product of a given integer multiplied by all positive integers less than itself. For example, 3!=3x2x1=6. (n must be positive. By definition 0!=1.)

**Example:** What is 7 factorial?
Press: 7 [MATH] [A] [5] [ENTER]
Result: 5040.

**6** `nCr` is the combinations function. This function calculates how many different groups of *r* items you can make out of *n* objects. The order of the items doesn't matter. For example, the group Marc, Marilyn, Ted is the same as Ted, Marilyn, Marc.

**Example:** How many different 3 person teams can you make out of a group of 15 players?
Press: 15 [MATH] [A] [6] 3 [ENTER]
Result: 455.

**7** `nPr` is the permutations function. This function calculates how many different arrangements of *r* items can be made out of *n* objects. The order of the items *does* matter. For example, the license plate MHJ is not the same as MJH.

**Example:** How many different 3 lettered license plates can you make out of the first 15 letters of the alphabet?
Press: 15 [MATH] [A] [7] 3 [ENTER]
Result: 2730.

The small arrow at the bottom of the menu indicates that some functions are not displayed. These functions can be displayed by using the cursor keys.

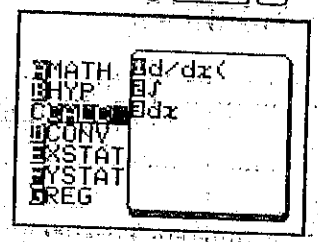
**8** `random` is the random function which displays a random number between 0.000 and 0.999.

**Example:** Have the calculator pick a number between 0 and 10.
Press: [MATH] [A] [8] [X] 10 [ENTER]
Result: A number between 0 and 9.99 appears.

The hyperbolic functions under the HYP menu were explained a few pages back. The next section describes the calculus functions.

## Calculus functions

Your calculator can integrate and differentiate many types of functions using numerical estimations. Pressing MATH C displays the following:




1 d/dx( selects the derivative function. This function estimates the first derivative[3] of a function at a given value. The syntax of the derivative function is:

d/dx(function , x [value] , Δx [change in x]). (Δx is optional.)

**Example:** If $F(x)=x^2+x$, find $F'(4)$.

Press: MATH C 1 X/θ/T x² + X/θ/T ALPHA , 4 ALPHA , 0.00001 ) ENTER

Result: 9.

[3] The formula for the derivative of a function is:

$$f'(x)=\lim_{\Delta x\to 0}\frac{f(x+\Delta x)-f(x)}{\Delta x}$$



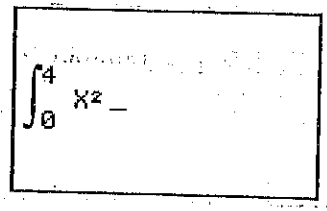


2 ∫ selects the integrate function. This calculates the area under a curve between two points. The calculator uses Simpson's rule[4] to partition the area into a number of even subintervals and estimate the answer. The calculator doubles the number of subintervals you specify. The answer is an estimate, and therefore will not be exactly correct.

**Example:** What is $\int_0^4 x^2\,dx$ calculated over 16 subintervals.

Press: SET UP F 1 ENTER MATH C 2
0 ▲ 4 ▶ X/θ/T x²

Displays:




Press: ALPHA , 8 (The comma marks the end of the equation, the 8 is one half the number of desired subintervals.)

Note: This step is optional. If no subinterval count is given, a default of 100 subintervals is used.

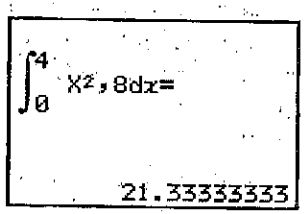
[4] Simpson's rule can be written:

$$\int_a^b f(x)dx=\frac{b-a}{3n}[f(x_0)+4f(x_1)+2f(x_2)+4f(x_3)+2f(x_4)\ldots+2f(x_{n-2})+4f(x_{n-1})+f(x_n)]$$

where the closed interval [a,b] is evenly partitioned into n subintervals of length $\frac{b-a}{n}$. This gives an estimate of the area under the curve.

Press: MATH C 3 ENTER

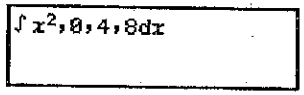
Displays:




Result: 21.33333333

**∎ dx** marks the end of an integration equation. The example above demonstrates its use.

When using the line editor (SET UP F 2) or programming mode (▶) the above integration must be entered like this:

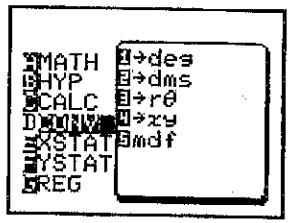



The syntax of integration in line edit mode is:

∫ Function, lower limit, upper limit, intervals, dx

## Conversions

Pressing MATH D displays the following:




**∎ ▸deg** converts a number expressed in degrees minutes seconds (sexagesimal) notation to degrees (decimal).

**Example:** What is the value of 7°56'24" in degrees?
Press: 7.5624 MATH D 1 ENTER
Result: 7.94 (7.94°)





**∎ ▸dms** converts a number expressed in degrees (decimal) to degrees minutes seconds (sexagesimal) notation.

**Example:** What is the sexagesimal value of 7.94°?
Press: 7.94 MATH D 2 ENTER
Result: 7.562400 (7°56'24"00)

**∎ ▸rθ** converts rectangular coordinates to polar coordinates.

**Example:** What is (1,1) in polar coordinates?
Press: SET UP B 1 ENTER 1 ALPHA , 1 MATH D 3
Result: 1.414213562
To see θ, press: ALPHA θ ENTER
Result: 45.

Polar coordinates are automatically stored in R and θ. The value of θ depends on the angular units selected.

**∎ ▸xy** converts polar coordinates into rectangular coordinates.

**Example:** What are the rectangular coordinates of (4,90)?
Press: SET UP B 1 ENTER 4 ALPHA , 90 MATH D 4
Result: 0.
To see Y, press: ALPHA Y ENTER
Result: 4.

The rectangular coordinates are automatically stored in X and Y.

**∎ mdf** is the modify function. When the calculator displays a value, it rounds the displayed version of the number to the selected number of decimal places. However, the calculator stores a more precise version of the number internally.

When you select mdf, the stored value is replaced with the displayed value. This function is only useful for decimal numbers.

Example: What is (1÷3) x 3?
Press: SET UP C 2 D 2 ENTER
1 ÷ 3 ENTER (0.33 is displayed) X 3 ENTER
Result: 1.00

Now do it again, but this time modify the displayed value.

Press: 1 ÷ 3 ENTER (0.33 is displayed)
MATH D 5 X 3 ENTER

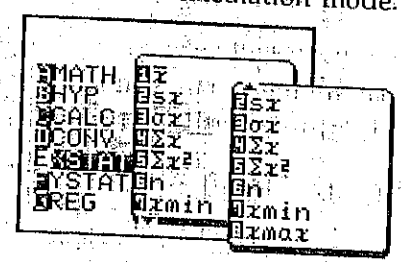
Result: 0.99

Return to floating point notation, SET UP C 1 ENTER.

## Statistics in calculations

Note: If data has not been entered in statistics mode, none of the following statistical variables are meaningful and may cause errors when used in equations.

In calculation mode you can use results from data entered in statistics mode. Statistics mode is explained in Chapter 6. The following single-variable statistical results are available in calculation mode:




These variables are defined as follows:

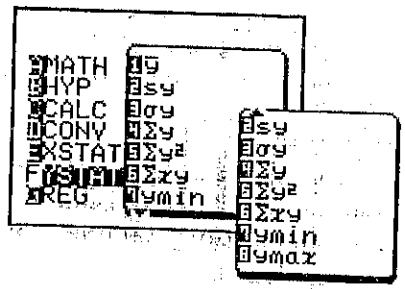
| | |
|---|---|
| x̄ | mean value of x data. |
| sx | sample standard deviation of x data. |
| σx | population standard deviation of x data. |
| Σx | sum of x data. |
| $\Sigma x^2$ | sum of the squares of the x data. |
| n | number of observations. |
| xmin | minimum x value. |
| xmax | maximum x value. |

Variables appear in equations as variables, not numbers. A number is returned only after ENTER is pressed.





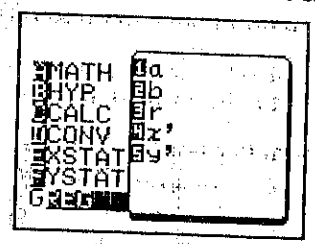
The following two-variable statistical results are available in calculation mode:




These variables are defined as follows:

| | |
|---|---|
| ȳ | mean value of y data. |
| sy | sample standard deviation of y data. |
| σy | population standard deviation of y data. |
| Σy | sum of y data. |
| $\Sigma y^2$ | sum of the squares of the y data. |
| Σxy | sum of the products of the xy pairs. |
| ymin | minimum y value. |
| ymax | maximum y value. |

The following regression results are available in calculation mode:




These variables are defined as follows:

| | |
|---|---|
| a | first coefficient of linear regression (y-intercept). |
| b | second coefficient of linear regression (slope). |

r sample correlation coefficient.

x' Estimated value of x, based on a given value of y, using linear regression. You must enter a y-value before using this function. The syntax is: *given y-valuex'* (for example, 5x' returns an x-value based upon a y-value of 5).

y' Estimated value of y, based on a given value of x, using linear regression. You must enter an x-value before using this function. The syntax is: *given x-valuey'* (for example, 25y' returns a y-value based upon an x-value of 25).

Note: The regression variables available in calculation mode are always based on linear regression.

# Nbase mode

While in calculation mode, press [MENU] [A]. Enter nbase mode by pressing 2, or use the cursor keys and press [ENTER].

Nbase mode lets you calculate and perform logical operations in binary (base 2), octal (base 8), decimal (base 10), and hexadecimal (base 16). In binary mode, the only active number keys are 0 and 1. In octal mode, the numbers 0 through 7 are active. In decimal mode, 0 through 9 are active. In hexadecimal mode, the numbers 0 through 9 and the letters A through F represent 0 through 15. (You don't have to press [ALPHA] to use these letters.)

Only integer values are represented in hexadecimal, octal, and binary modes. The [.] key is ignored by the calculator and exponents are not active.

The maximum value of a number in hexadecimal and octal modes is limited to 10 digits. The maximum value of a number in binary mode is limited to 16 digits.

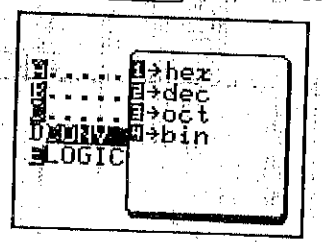
Negative numbers are represented in two's complement notation (the complement of the number plus 1).





## Selecting bases

After entering nbase mode, press [MATH] and the following menu appears:

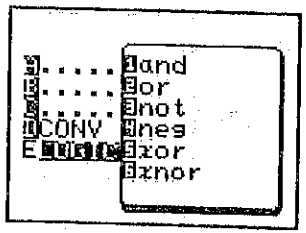



You can convert a number in the display into the selected base (if the number can be converted). If the number cannot be converted an error results. The conversion function places the calculator in the new base mode. For example, selecting the first option sets the calculator to hexadecimal mode. The calculator remembers the selected base when you leave nbase mode or turn off the calculator.

**Example:** Convert 214(base 10) to hexadecimal then to binary.
Press: [MENU] [2] [MATH] [D] [2] 214 [MATH] [D] [1]
Result: 00000000D6 (In hexadecimal, now convert it to binary)
Press: [MATH] [4]
Result: 0000000011010110
The calculator is now in binary mode.

## Logical operations

Your calculator performs six logical operations. The logic menu appears when you press MATH E:




**and** is defined as follows:

| x | 1 | 1 | 0 | 0 |
|---|---|---|---|---|
| y | 1 | 0 | 1 | 0 |
| x AND y | 1 | 0 | 0 | 0 |

AND compares the binary digits of two numbers and returns a 1 for each matching pair of 1's. For example, 101010 AND 111000 equals 101000. AND compares them as follows:

| | |
|---|---|
| x | 101010 |
| y | 111000 |
| x AND y | 101000 |

**Example:** In hex mode, what is C AND 9?
**Press:** MATH D 1 C MATH E 1 9 ENTER
**Result:** 0000000008





**or** is defined as follows:

| x | 1 | 1 | 0 | 0 |
|---|---|---|---|---|
| y | 1 | 0 | 1 | 0 |
| x OR y | 1 | 1 | 1 | 0 |

OR compares the binary digits of two numbers and returns a 1 for each 1 found. For example, 101010 OR 111000 equals 111010. OR compares them as follows:

| | |
|---|---|
| x | 101010 |
| y | 111000 |
| x OR y | 111010 |

**Example:** In hex mode, what is C OR 9?
**Press:** MATH D 1 C MATH E 2 9 ENTER
**Result:** 000000000D

**not** is defined as follows:

| x | 1 | 0 |
|---|---|---|
| NOT x | 0 | 1 |

NOT switches each binary digit of a number to the opposite binary digit including leading zeros. The number (NOT x ) is the complement of x. For example, NOT 101010 equals 1111111111010101. NOT inverts the digits as follows:

| | |
|---|---|
| x | 0000000000101010 |
| NOT x | 1111111111010101 |

**Example:** In hex mode, what is NOT C?
**Press:** MATH D 1 MATH E 3 C ENTER
**Result:** FFFFFFFFF3

■ `neg` converts a number to negative. Since the calculator displays negative numbers in two's complement notation, NEG inverts the number (like NOT) and then adds 1.

NEG switches each binary digit of a number to the opposite binary digit including leading zeros and then adds 1. For example, NEG 101010 equals 1111111111010110. NEG inverts the digits as follows:

| | |
|---|---|
| x | 0000000000101010 |
| invert | 1111111111010101 |
| and add 1 | +1 |
| x NEG | 1111111111010110 |

**Example:** In hex mode, what is NEG C + C?
Press: C [MATH] [D] [1] [MATH] [E] [4] C [+] C [ENTER]
Result: 0000000000

■ `xor` is defined as follows:

| x | 1 | 1 | 0 | 0 |
|---|---|---|---|---|
| y | 1 | 0 | 1 | 0 |
| x XOR y | 0 | 1 | 1 | 0 |

XOR (exclusive OR) compares each binary digit of two numbers and returns a 1 when either digit contains a 1, but not both. For example, 101010 XOR 111000 equals 010010. XOR compares them as follows:

| | |
|---|---|
| x | 101010 |
| y | 111000 |
| x XOR y | 010010 |

**Example:** In hex mode, what is C XOR 9?
Press: [MATH] [D] [1] C [MATH] [E] [5] 9 [ENTER]
Result: 0000000005





■ `xnor` is defined as follows:

| x | 1 | 1 | 0 | 0 |
|---|---|---|---|---|
| y | 1 | 0 | 1 | 0 |
| x XNOR y | 1 | 0 | 0 | 1 |

The operation x XNOR y is simply NOT(x XOR y). For example, 101010 XNOR 111000 equals 1111111111101101. XNOR compares them as follows:

| | |
|---|---|
| x | 101010 |
| y | 111000 |
| x XOR y | 010010 |
| NOT!= | |
| x XNOR y | 1111111111101101 |

**Example:** In hex mode, what is C XNOR 9?
Press: [MATH] [D] [1] C [MATH] [E] [6] 9 [ENTER]
Result: FFFFFFFFFA

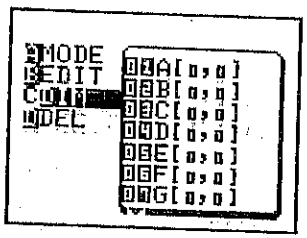
# Matrix mode

Matrix mode lets you perform matrix operations and define matrix elements.

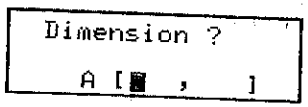
While in calculation mode, press [MENU] [A]. Enter matrix mode by pressing 3, or use the cursor keys and press [ENTER].

## Defining a matrix

After entering matrix mode, press [MENU] [C] and the following menu appears:



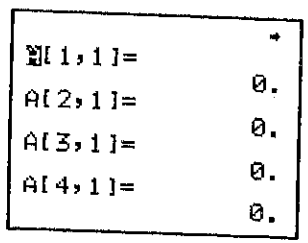

This option lets you define (and store) up to 26 different matrices. The matrices are stored even after the mode has been changed or the calculator has been turned off. To define the dimensions of a matrix, press 01 (or use the cursor keys to select a matrix and press [ENTER]). The following display appears:




Note: Redefining a matrix that already exists erases all of the information in that matrix. If you don't want to erase an existing matrix, press [QUIT] and select a different matrix.

Enter the number of rows and the number of columns. For example, to define a matrix with four rows and three columns, press 4 [ENTER] 3 [ENTER].

The first column of the matrix appears:








Use the keypad to enter the matrix elements and press [ENTER]. Each element of the matrix is labeled with its associated coordinate (matrix index [row number, column number]). Use the cursor keys to move around the matrix (through the row and column elements). Arrow indicators show you which directions you can move. [▼] and [▲] move through the rows, [◄] and [►] move through the columns. You can enter numbers, variables, and equations for each matrix element. (The final calculated value is stored.) Press [QUIT] to exit the matrix.

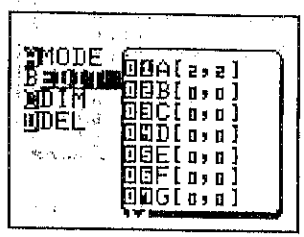
**Example:** Find the determinant of: $\begin{vmatrix} 1 & 3 \\ 2 & 4 \end{vmatrix}$

Press: [MENU] [C] [0] [1] 2 [ENTER] 2 [ENTER] (Defines a 2x2 matrix)
1 [ENTER] 2 [ENTER] 3 [ENTER] 4 [ENTER] [QUIT]
[MATH] [E] [6] [MAT] A [ENTER] ([2ndF] is not required)

Result: -2.

## Editing a matrix

After entering matrix mode, press [MENU] [B] and the following menu appears:




To edit a matrix, enter its two digit number, or use the cursor keys to select a matrix and press [ENTER]. The first column of the matrix appears. Use the cursor keys to position the cursor on a matrix element, enter a new number, variable, or equation and press [ENTER].

**Example:** Change Matrix A $\begin{vmatrix} 1 & 3 \\ 2 & 4 \end{vmatrix}$ to $\begin{vmatrix} 11 & 3 \\ 2 & 4 \end{vmatrix}$

Press: [MENU] [B] [0] [1]
Press: 11 [ENTER]
Result:

```
A[1,1]=
A[2,1]=        11.
               2.
```

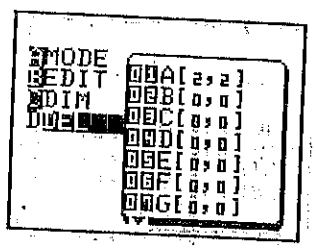
Press: [▶]
Result:

```
A[1,2]=
A[2,2]=        3.
               4.
```

Press: [QUIT]

## Deleting a matrix

After entering matrix mode, press [MENU] [D] and the following menu appears:




To delete a matrix, enter its number, or select it with the cursor keys and press [ENTER].

**Example:** Delete matrix B
Press: [MENU] [D] [0] [2]
Result: [ENTER] to delete the matrix, press [QUIT] to exit.
If you pressed [ENTER], the matrix was deleted.

## Matrix function keys

Except for [i], [X/θ/T] and [∠], all of the keyboard function keys are available in matrix mode.





[MAT] is the matrix identifier function. This function key tells the calculator that a matrix is being referenced. After pressing [MAT], you do not need to press [ALPHA] to select the matrix index. Use the matrix identifier to specify matrices used in calculations.

**Example:** Calculate Matrix A: $\begin{vmatrix} 11 & 3 \\ 2 & 4 \end{vmatrix}$ + Matrix B: $\begin{vmatrix} 1 & 16 \\ 31 & 41 \end{vmatrix}$

(First, create the above matrices using the steps described earlier.)
Press: [MAT] A [+] [MAT] B [ENTER]
Result:

```
ANS[1,1]=
ANS[2,1]=      12.
               33.
```

Press: [▶]
Result:

```
ANS[1,2]=
ANS[2,2]=      19.
               45.
```

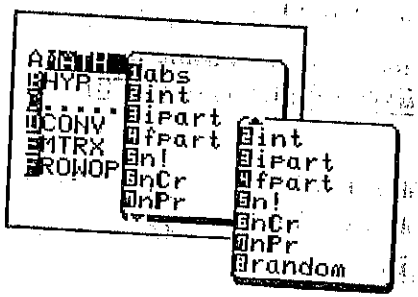
Press: [QUIT]

Matrix 27 (ANS) is reserved for matrix operation results. Press [QUIT] to exit the ANS (or any other) matrix.

Two of the function keys ([$x^{-1}$] and [$x^2$]) perform operations that are very different from their operation in other modes. [$x^{-1}$] calculates the inverse of a square matrix. [$x^2$] calculates the square of a square matrix. Matrix A divided by Matrix B is the same as Matrix A x Matrix $B^{-1}$.

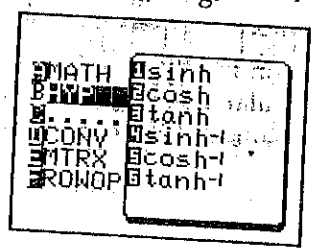
## Matrix math functions

Matrix mode has many of the same math functions as real mode. To access the menu functions press [MATH]. The following math functions are available:




These are the same functions described in the section called *"Absolute values, integers, factorials, combinations, permutations, and random numbers."* You can use these functions while entering matrix elements, or while performing matrix operations (for example, A[1,2]=25!, or abs det mat A).

Pressing [MATH] [B] displays the following:

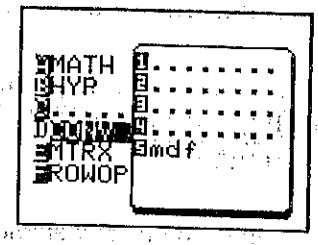



This menu lets you use hyperbolic trigonometric functions. To see some examples of their use, see the section called *"Hyperbolic sines, cosines, and tangents."*



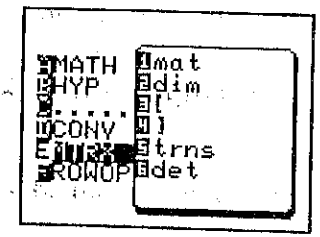


Pressing [MATH] [D] displays the following:




**5 mdf** is the same modify function explained earlier in this chapter.

Pressing [MATH] [E] displays the following:




**1 mat** is the matrix specifier. This function is also available on the keyboard.

**dim** is the dimension function. This function lets you define a matrix without using [MENU]. Use this function to define a matrix while programming.

**Example:** Define matrix H to be a 4 by 5 matrix.
Press: [MATH] [E] [2] H [MATH] [E] [3] 4 [ALPHA] [,] 5 [MATH] [E] [4] [ENTER]

You can now enter values for all of the matrix elements, or press [QUIT] and enter them later.

**[** and **]** are open and close brackets. Use them to reference individual matrix elements, and when using the dim function.

**Example:** What is the value of A[1,2]?
Press: [ALPHA] A [MATH] [E] [3] 1 [ALPHA] [,] 2 [MATH] [4] [ENTER]
Result: 3.

Do not use the matrix key when viewing individual matrix elements.

Note: You can view all values of a matrix by pressing [MAT] *matrix letter* [ENTER].

**trns** is the transpose function. This function flips an $m \times n$ matrix along its main diagonal, creating an $n \times m$ matrix. The first row of the original matrix is the first column of the transposed matrix, the second row of the original matrix is the second column of the transposed matrix, and so on.





**Example:** Calculate the transpose of Matrix B: $\begin{vmatrix} 11 & 16 \\ 31 & 41 \\ 55 & 97 \end{vmatrix}$

(First, create Matrix B.)
Press: [MATH] [E] [5] [MAT] B [ENTER]

Result:

```
ANS[1,1]=
                 11.
ANS[2,1]=
                 16.
```

Press: [▶]
Result:

```
ANS[1,2]=
                 31.
ANS[2,2]=
                 41.
```

Press: [▶]
Result:

```
ANS[1,3]=
                 55.
ANS[2,3]=
                 97.
```

Press: [QUIT]

**det** is the determinant function. This function calculates the determinant of a *square* matrix.

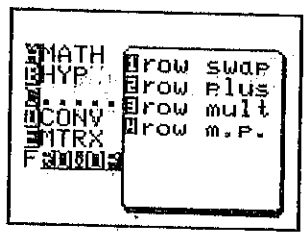
**Example:** Calculate the determinant of Matrix C: $\begin{vmatrix} 1 & 2 & 3 \\ 0 & 5 & 6 \\ 0 & 0 & 9 \end{vmatrix}$

(First, enter Matrix C.)
Press: [MATH] [E] [6] [MAT] C [ENTER]

Result: 45.

Note: The matrix must be square (number of rows equals the number of columns).

Pressing [MATH] F displays the following:




1 row swap switches any two rows of a matrix. The syntax is: row swap(*matrix letter, row1, row2*).

**Example:** Swap the first and second rows of matrix C: $\begin{vmatrix} 1 & 2 & 3 \\ 0 & 5 & 6 \\ 0 & 0 & 9 \end{vmatrix}$

Press: [MATH] [F] [1] [ALPHA] C [ALPHA] [,] 1 [ALPHA] [,] 2 [)] [ENTER]

Result:

```
ANS[1,1]=
ANS[2,1]=      0.
ANS[3,1]=      1.
               0.
```

Press: [▶]

Result:

```
ANS[1,2]=
ANS[2,2]=      5.
ANS[3,2]=      2.
               0.
```

Press: [▶]

Result:

```
ANS[1,3]=
ANS[2,3]=      6.
ANS[3,3]=      3.
               9.
```

Press: [QUIT]





2 row plus adds any two rows together and stores the result in the second row specified. The syntax is row plus(*matrix letter, row1, row2*).

**Example:** Add the first and second rows of matrix C: $\begin{vmatrix} 1 & 2 & 3 \\ 0 & 5 & 6 \\ 0 & 0 & 9 \end{vmatrix}$

Press: [MATH] [F] [2] [ALPHA] C [ALPHA] [,] 1 [ALPHA] [,] 2 [)] [ENTER]

Result:

```
ANS[1,1]=
ANS[2,1]=      1.
ANS[3,1]=      1.
               0.
```

Press: [▶]

Result:

```
ANS[1,2]=
ANS[2,2]=      2.
ANS[3,2]=      7.
               0.
```

Press: [▶]

Result:

```
ANS[1,3]=
ANS[2,3]=      3.
ANS[3,3]=      9.
               9.
```

Press: [QUIT]

**row mult** multiplies a row by a scalar. The syntax is row mult(*scalar, matrix letter, row*).

**Example:** Multiply 4 times the first row of matrix C: $\begin{vmatrix} 1 & 2 & 3 \\ 0 & 5 & 6 \\ 0 & 0 & 9 \end{vmatrix}$

Press: [MATH] [F] [3] 4 [ALPHA] [,] [ALPHA] C [ALPHA] [,] 1 [)] [ENTER]

Result:

```
ANS[1,1]=
ANS[2,1]=        4.
ANS[3,1]=        0.
                 0.
```

Press: [▶]

Result:

```
ANS[1,2]=
ANS[2,2]=        8.
ANS[3,2]=        5.
                 0.
```

Press: [▶]

Result:

```
ANS[1,3]=
ANS[2,3]=       12.
ANS[3,3]=        6.
                 9.
```

Press: [QUIT]





**row m.p.** multiplies a row by a scalar, adds the row to a second row and stores the result in the second row specified. The syntax is row m.p.(*scalar, matrix letter, row1, row2*).

**Example:** Multiply 2 times the first row of matrix C: $\begin{vmatrix} 1 & 2 & 3 \\ 0 & 5 & 6 \\ 0 & 0 & 9 \end{vmatrix}$ and add the result to the second row.

Press: [MATH] [F] [4] 2 [ALPHA] [,] [ALPHA] C [ALPHA] [,] 1 [ALPHA] [,] 2 [)] [ENTER]

Result:

```
ANS[1,1]=
ANS[2,1]=        1.
ANS[3,1]=        2.
                 0.
```

Press: [▶]

Result:

```
ANS[1,2]=
ANS[2,2]=        2.
ANS[3,2]=        9.
                 0.
```

Press: [▶]

Result:

```
ANS[1,3]=
ANS[2,3]=        3.
ANS[3,3]=       12.
                 9.
```

Press: [QUIT]

Note: You can store the result of a matrix calculation into another matrix by pressing [STO] [MAT] *letter* instead of pressing [ENTER].

Data entered in statistics mode can be stored in, or retrieved from, a matrix; for more information, see Chapter 6.

# Complex mode

Complex mode lets you perform calculations with complex numbers.

While in calculation mode, press [MENU] [A]. Enter complex mode by pressing 4, or use the cursor keys and press [ENTER].

Complex numbers can be written in two forms: $a \pm bi$, or $r\angle\theta$. In rectangular coordinate form (a±bi), $a$ is the real part and $bi$ is the imaginary part. In polar coordinate form (r∠θ), $r=\sqrt{a^2+b^2}$ (the distance from the origin), and $\theta$ is the angle.

Note: Complex numbers have only 8-digit mantissas in scientific notation.

Use [SET UP] to set polar or rectangular complex coordinates. See *"Complex coordinates"* for more information.

Except for [MAT], all of the keyboard function keys of the EL-9300 can be used in complex mode.

Note: In complex mode, the EL-9200 has only basic arithmetic operations available (+, -, x, ÷).

**Example:** $(3 + 2i) \times (3 - 4i)$
Press: [(] 3 [+] 2 [2ndF] [i] [)] [X] [(] 3 [÷] 4 [2ndF] [i] [)] [ENTER]
Result: 17.-6.*i*

Note: In complex mode all trigonometric functions use radians regardless of the angular units selected. The selected angular units affect only the complex numbers written in polar coordinates form (r∠θ).

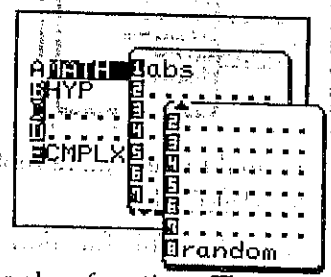
**Example:** $(2\angle 30°)+(3+4i)$
Press: [SET UP] [B] [1] [ENTER]
[(] 2 [2ndF] [∠] 30 [)] [+] [(] 3 [+] 4 [2ndF] [i] [)] [ENTER]
Result: 4.7320508+5.*i*
Press: [SET UP] [H] [2] [ENTER]
Result: 6.8842069∠46.577106





## Complex functions

To access the math menu functions of complex mode, press [MATH] and the following menu appears:

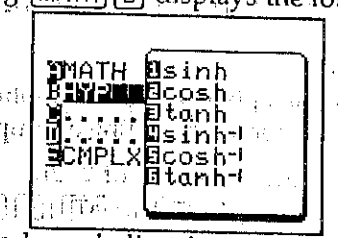



**1** abs is the absolute value function. The absolute value of a complex number is equal to r in its polar coordinate representation r∠θ.

Example: |3+4*i*|
Press: [MATH] [A] [1] [(] 3 [+] 4 [2ndF] [i] [)] [ENTER]
Result: 5.

**8** random is described in detail in the section called *"Absolute values, integers, factorials, combinations, permutations, and random numbers"* earlier in this chapter.

On the EL-9300, pressing [MATH] [B] displays the following:




This menu lets you use hyperbolic trigonometric functions. To see some examples of their use, see the section called *"Hyperbolic sines, cosines, and tangents."* In complex mode all inverse trigonometric functions use radians regardless of the angular units selected.

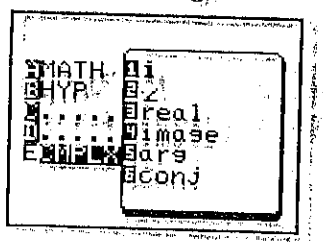
On the EL-9300, you can use the following functions with complex numbers:

$\sin$, $\cos$, $\tan$, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, log, ln, $10^x$, $e^x$, $a^b$, $\sqrt[a]{\ }$, $\sqrt{\ }$, $x^{-1}$, $x^2$, abs

On the EL-9200, you can use the following functions with complex numbers:

$x^{-1}$, $x^2$, abs

Pressing MATH E displays the following:




**1** `i` is the imaginary number equal to the square root of -1. This function is also available on the keyboard (2ndF i).

**2** ∠ is the polar coordinate separator. This function is also available on the keyboard (2ndF ∠).

**3** `real` returns the real portion of a complex number.

**Example:** What is the real portion of 12+3*i*?
Press: MATH E 3 ( 12 + 3 2ndF i ) ENTER
Result: 12.

**4** `image` returns the imaginary portion of a complex number.

**Example:** What is the imaginary portion of 12+3*i*?
Press: MATH E 4 ( 12 + 3 2ndF i ) ENTER
Result: 3.

**5** `arg` returns the argument of a given complex number (equal to $\tan^{-1}(b/a)$). The argument is the angle θ when representing a complex number as r∠θ.

**Example:** What is the argument of 2+2*i*?
Press: SET UP B 1 ENTER MATH E 5 ( 2 + 2 2ndF i ) ENTER
Result: 45. (degrees)

**6** `conj` returns the complex conjugate of a given complex number. The complex conjugate of a+b*i* is a-b*i*.

**Example:** What is the complex conjugate of 12+3*i*?
Press: SET UP H 1 ENTER MATH E 6 ( 12 + 3 2ndF i ) ENTER
Result: 12.-3.*i*



# CHAPTER 4: Graphing

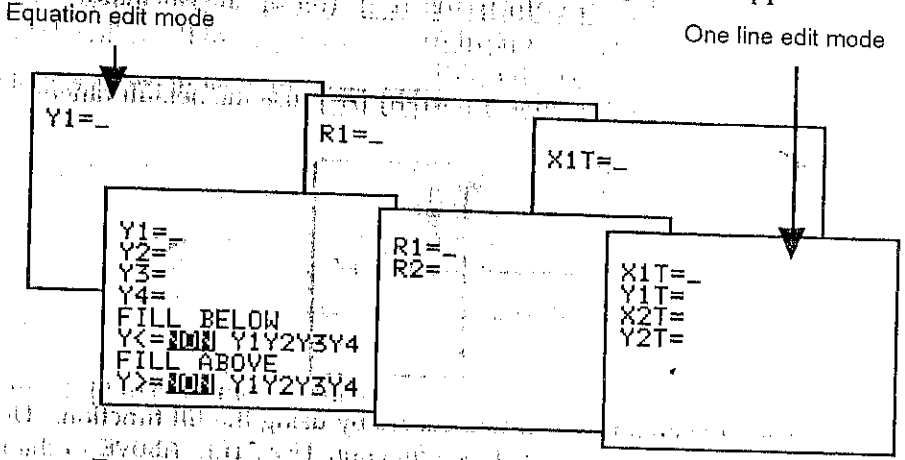
This chapter describes graphing equations in rectangular or polar coordinates, and graphing parametric equations. Tracing and filling functions, defining ranges, plotting points and lines, and zooming are also described.

The general procedure for graphing equations is:

1. Enter graph mode.
2. Key-in one or more functions.
3. Specify the range of the x- and y-axis.
4. Press A/a or 2ndF AUTO.

## Entering graph mode

Press A/a to enter graph mode. Depending on how you have selected the coordinates in the set up menu, one of the following screens appears:




***Rectangular (XY), polar (R0), and parametric (XYT) screens.***

To select coordinates, press [SET UP] [E]. For more information, see *"Coordinates"* near the end of Chapter 2.

## Rectangular coordinates

Rectangular coordinate mode is the default graph mode. You can simultaneously graph up to four functions in this mode.

After entering graph mode, use the keyboard and [MATH] menus to enter a function (an equation or a number) and then press [ENTER]. The cursor will move to start of the next function.

If there are any previous functions, use [CL] to clear them.

If you want to move between functions, press [▼] or [▲] (if you are in equation edit mode, you must press [2ndF] [▼] or [2ndF] [▲]). Pressing [MENU] displays a menu that lets you jump directly to any equation.

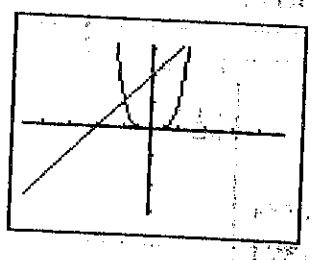
Before you graph a function, you must set a range. The easiest way to set the range is to use the auto scaling feature. Press [RANGE], enter a minimum, maximum, and scale value for x, and press [2ndF] [AUTO]. For more information, see *"Ranges"* below.

This example shows some of the powerful graphing features:

**Example:** Graph $y=x^4$ and $y=x+2$.

Press: [↗] [SET UP] [E] [1] [ENTER] (set up the calculator)
[X/θ/T] [a^b] 4 [ENTER]
[X/θ/T] [+] 2 [ENTER]
[RANGE] [MENU] [ENTER] [↗] (use the default range)

Result:



You can shade the area between two curves by using the fill functions. Use FILL BELOW to shade an area below a function. Use FILL ABOVE to shade



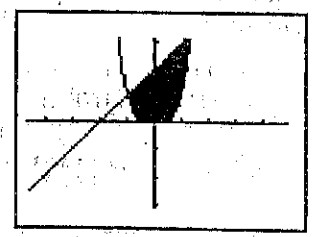


an area above a function. To select a fill option, simply highlight the option using [◄] and [►].

**Example:** Now fill in the area that is above $x^4$ *and* below $x+2$.

Press: [MENU] [5] [►] [►] [ENTER] [►] [↗]

Result:

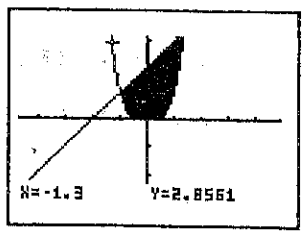


As shown above, if both FILL BELOW and FILL ABOVE are selected and the curves intersect, only the area between the curves is shaded.

To move along either curve (this is called tracing a curve), press [►]. The x and y coordinates will appear on the bottom of the screen, and a crosshair appears on the graph indicating the current position of the cursor. Use [◄] or [►] to move left or right. Use [▼] or [▲] to move from one curve to another. If you are tracing Y1 and you press [▲], nothing happens since you are on the first equation. Use [2ndF] [►] or [2ndF] [◄] to move to the displayed endpoints of a curve. If you attempt to go past the displayed endpoints, the graph will scroll to keep the cursor on the screen.

Here is an example of the trace function:

[►]




Press [CL] to clear the coordinates.

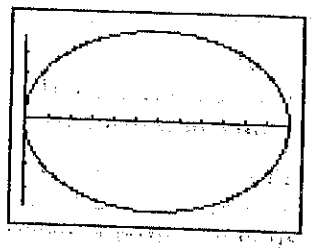
## Polar coordinates

Polar coordinates graph (r,θ), where r is the distance from the origin and θ is an angle measured from the positive x-axis. When polar coordinates are selected, pressing [X/θ/T] enters a θ in the graph equation screen. You can graph two equations simultaneously.

**Example:** Graph R=cos θ using polar coordinates.

Press: [SET UP] [E] [2] [B] [2] [ENTER]
[cos] [X/θ/T] [ENTER] [RANGE] 0 [ENTER]
[2ndF] [π] [ENTER] [2ndF] [AUTO]

Result:



The graph of r=cos θ is not a circle because it is distorted. Auto scale sets the length of the x-axis to 1 unit and the length of the y-axis to 1 unit to use as much of the screen as possible. Since the screen is one and a half times wider than it is long, the circle appears elongated. Change the x-range maximum to 1.5 ([RANGE] [▶] [▼] 1.5 [ENTER] [Graphing]) and a circle appears.





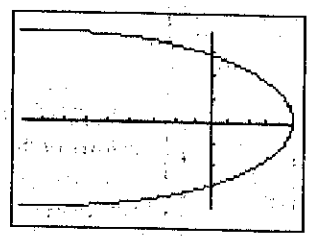
## Parametric equations

Equations that depend on a third variable to define their points on a plane [x=x(t), y=y(t)] are called parametric equations. The calculator increments t by Tstp to graph each point. When parametric coordinates are selected, pressing [X/θ/T] enters a T in the graph equation screen. You can graph two equations simultaneously.

**Example:** Graph x=3sinT-2, y=2cosT.

Press: [SET UP] [E] [3] [B] [2] [ENTER]
3 [sin] [X/θ/T] [-] 2 [ENTER]
2 [cos] [X/θ/T] [ENTER] [RANGE] 0 [ENTER]
[2ndF] [π] [ENTER] [2ndF] [AUTO]

Result:

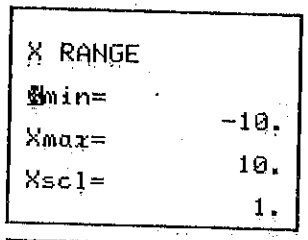
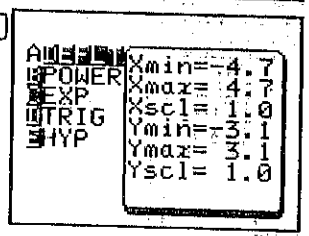
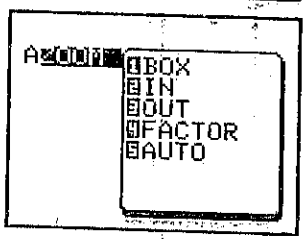
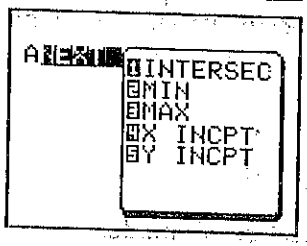


The angular units selected under DRG of the set up menu affect all equations involving trigonometric functions. Make sure you are using the angular units you want.

# Graph function keys

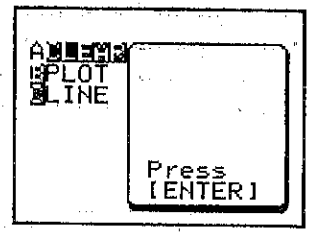
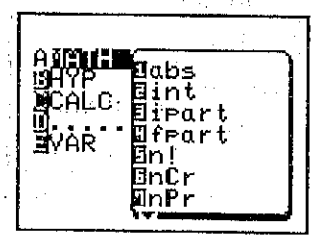
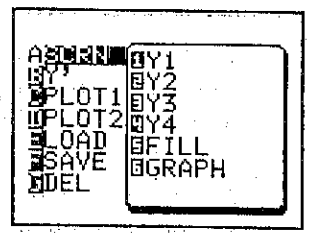
The following is a list of keys that affect graph mode:

| KEY | MENU | FUNCTION |
|---|---|---|
| [Graphing] | none | Enters graph mode. If you are already in graph mode, pressing this key graphs the functions entered. |
| [EQTN] | none | Returns you to equation entry screen. |

| KEY | MENU | FUNCTION |
|---|---|---|
| RANGE |  | Lets you specify the area of the graph you want see and set the axes' tick-mark annotation. |
| RANGE MENU |  | Restores RANGE settings to initial values. Also sets the ranges for functions B to E automatically. |
| ZOOM |  | Lets you draw a box to set the range, zoom in or out, and set the zoom factors. This is an easier way to change the viewing window. |
| 2ndF JUMP |  | Lets you jump to intersection points, minimum and maximum values, and x and y intercepts. These functions are only available in rectangular coordinate mode. |
| | | Note: A discontinuous function may be regarded as a continuous function to find intersection points. |
| 2ndF AUTO | none | Auto scales the graph. Does not change the θ RANGE or T RANGE. In rectangular coordinate mode it does not change the X RANGE. |

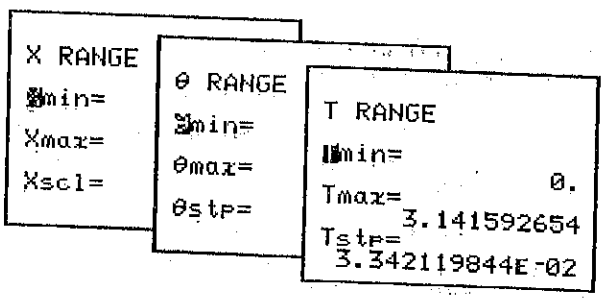




| KEY | MENU | FUNCTION |
|---|---|---|
| 2ndF PLOT |  | Lets you draw points or lines on the screen.<br>Also clears PLOT. |
| MATH |  | Lets you enter math functions to create equations for graphing. Available only while entering equations. |
| MENU |  | Lets you choose specific functions, view the derivative of a function, control graph features, and load, save, and delete graph files. |
| QUIT | none | Exits any menu and returns you to the previous screen. See EQTN. |

## Ranges

You can set the displayed bounds and scale of the axes with [RANGE]. Changing a range can significantly change a graph's perspective. Set the range so you see the part of the graph you are most interested in viewing. Press [RANGE] and, depending on the selected coordinate system, one of the following appears:




*Rectangular, polar, and parametric range screens.*

If rectangular coordinates are selected, the X RANGE screen lets you change the minimum (Xmin) and maximum (Xmax) points of the displayed x-axis. Xscl (x-scale) sets the scale of the tick-marks on the x-axis. You can change any of these settings.

Move to the Y RANGE screen by pressing [▶]. The Y RANGE screen displays the minimum (Ymin) and maximum (Ymax) points of the y-axis. Yscl sets the scale of the tick-marks on the y-axis.

The X RANGE and Y RANGE screens are common to all graph modes.

If polar coordinates are selected ([SET UP] [E] [2]), θ RANGE displays the minimum and maximum values for θ. θstp selects the θ step factor (how much θ changes before the next point is plotted). Press [▶] to move to the x and y range screens. When tracing functions, θ changes by θstp with each press of [◀] or [▶].

If you set the θ range, you can press [2ndF] [AUTO] and the x and y ranges will be scaled automatically. The θ RANGE remains in effect even if you redefine the functions being drawn. θstp changes in relation to the minimum and





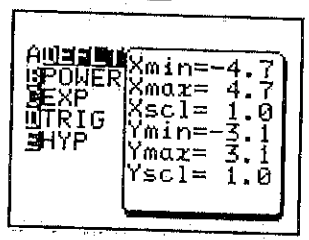
maximum values of θ.[5] If you enter θstp, θmax is recalculated. If you enter θmax, θstp is recalculated.

If parametric coordinates are selected ([SET UP] [E] [3]), T RANGE displays the minimum and maximum values for T. Tstp selects the T step factor (how much T changes before the next point is plotted). Press [▶] to move to the x and y range screens. When tracing functions, T changes by Tstp with each press of [◀] or [▶].

If you set the T RANGE, you can press [2ndF] [AUTO] and the x and y ranges will be scaled automatically. The T RANGE remains in effect even if you redefine the functions being drawn. Tstp changes in relation to the minimum and maximum values of T.[6] If you enter Tstp, Tmax is recalculated. If you enter Tmax, Tstp is recalculated.

### The range menu

While in the range screen, press [MENU] and the following appears:



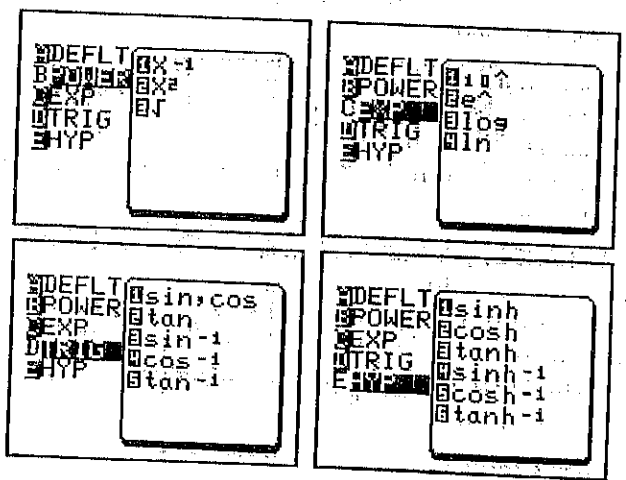

This menu lets you select predefined ranges that are appropriate for common functions graphed in rectangular coordinates. To select the default press [ENTER].

---

5 $\frac{\theta max-\theta min}{\theta stp}=90$ (maximum number of points drawn per polar screen)

6 $\frac{Tmax-Tmin}{Tstp}=94$ (maximum number of points drawn per parametric screen)

The other menus are:



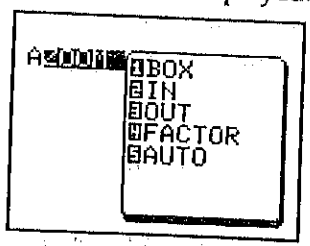

In general, select the predefined range that resembles your function. For example, if your function is y=log x/3, select C 3 (log).

The trigonometric ranges are automatically adjusted for the angular units selected in the set up menu (Deg, Rad, or Grad).

## Zooming

The zoom feature lets you change the range of the graph without entering specific numbers for each coordinate.

Press [ZOOM] and the following menu is displayed:




**A** BOX lets you draw a box around an area of interest. The boxed area then fills the entire screen, distorting the graph as necessary. After BOX is





selected move the cursor to a starting point for the box and press [ENTER]. Move the cursor diagonally to draw a box and press [ENTER].

**B** IN zooms in on the graph by an amount determined by FACTOR. If you use the trace feature to select a point on the curve (before you zoom in), that point becomes the screen center.

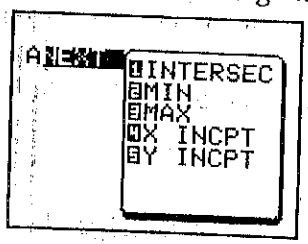
**C** OUT zooms out on the graph by an amount determined by FACTOR. If you use the trace feature to select a point on the curve (before you zoom out), that point becomes the screen center.

**D** FACTOR lets you set the zoom factor (the number that the range is divided by when zooming in, or multiplied by when zooming out). The x-factor can differ from the y-factor.

**E** AUTO performs the same function as pressing [2ndF] [AUTO]. (see page 86)

## Jump

The jump function jumps to the next (from left to right) point of interest on the screen. Press [2ndF] [JUMP] and the following menu appears:




**A** INTERSEC jumps to the next intersection of any two functions and displays the coordinates on the screen. The calculator may not be able to find the intersection if multiple roots exist.

**B** MIN jumps to a function's next minimum value (moving left to right). Since the calculator estimates the minimum, answers are approximate.

**C** MAX jumps to a function's next maximum value (moving left to right). Since the calculator estimates the maximum, answers are approximate.

**D** X INCPT jumps to where a function crosses the x-axis.

**E** Y INCPT jumps to where a function crosses the y-axis.

It may appear as if the cursor is not exactly at a point of intersection. This is due to the graph resolution. The displayed value and cursor position are correct.

## Auto

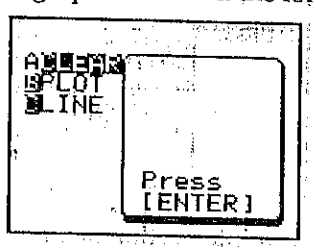
The auto scale function, automatically scales the range of the y-axis when using rectangular coordinates. The auto scale function looks at the x range, computes the maximum and minimum values for y in that range, and then sets an appropriate y range. If you get unexpected results from this function, check the new y range settings.

When graphing in polar coordinates, [2ndF] [AUTO] sets the x and y range based upon the θmin and θmax values.

When graphing parametric equations, [2ndF] [AUTO] sets the x and y range based upon the Tmin and Tmax values.

## The plot menu

Press [2ndF] [PLOT] while in graph mode and the following menu appears:




ACLEAR clears the entire graph area when you press [ENTER].

BPLOT lets you draw dots on the screen. PLOT has two options, DIRECT and FREE.

- DIRECT prompts you for an x and y coordinate and draws a single point.
- FREE lets you use the cursor keys to move around the screen and draw a dot whenever [ENTER] is pressed. The cursor's coordinates are displayed at the bottom of the screen.





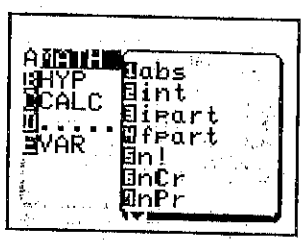
CLINE lets you draw lines on the screen. LINE also has two options, DIRECT and FREE.

- DIRECT prompts you for two x and y coordinates and draws a single line that connects them.
- FREE lets you use the cursor keys to move around the screen and draw line segments. Press [ENTER] to select the starting point, move to the ending point and press [ENTER] again to draw the line. You can continue to draw connected lines by moving to a new location and pressing [ENTER].

Plot functions remain on the screen until a graph is redrawn or CLEAR is selected.

## The math menu

The [MATH] menu provides many of the math functions presented in calculation mode:

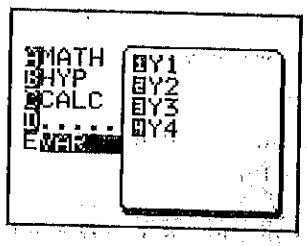



AMATH and BHYP are functions described in Chapter 3.

CCALC has only one option: d/dx(, unlike calculation mode, you do not need to enter an x-value or Δx-value. The derivative will be automatically calculated at the various x-values. Therefore, the syntax is simply d/dx(*function*). For example, $Y1=x^2$, Y2=d/dx(Y1) are valid functions.

Note: On the EL-9200, d/dx cannot be used in graph functions or graph programs.

VAR has the following four options:

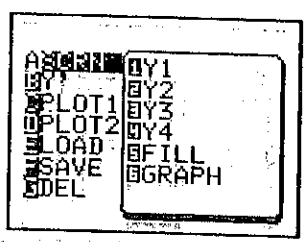



These options let you use graph functions within a function. For example, you can define Y1=sin(x+5)-cos (x), and Y2= ipart(Y1).

You cannot have self-referencing functions (for example, Y4=Y4+1 is not a valid function).

## The graph menu

Press [MENU] while in graph (XY) mode and the following menu appears:




SCRN lets you quickly jump to a desired equation or one of the fill functions. Y1 puts the cursor on equation Y1, Y2 puts the cursor on equation Y2, and so on. GRAPH, like [A], graphs the defined functions.

Y' turns the trace derivative function on or off. If Y' is set to ON the value of the derivative of the function at the current x appears on the screen with the x and y coordinates when tracing. Y' is only available when coordinates are set to rectangular (XY).

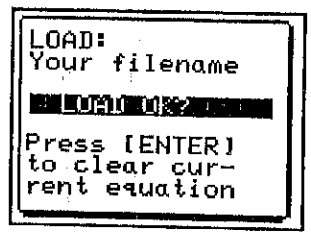
PLOT1 selects whether points are connected (Connect) or discrete dots (Dot).

PLOT2 selects whether the functions should be drawn one after the other (Sequence) or all at the same time (Simul).



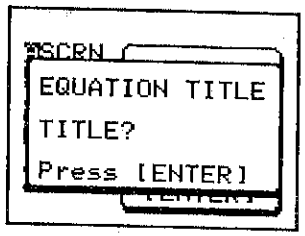


LOAD recalls stored graph files. (Select file from sub menu displayed) Loading a stored function clears the current equation. The following warning message appears:



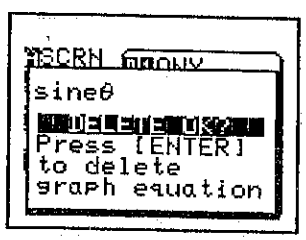

Press [QUIT] to exit without loading.

SAVE saves the current graph setup and functions as a file. Files include all range, screen, and function information. When you press [MENU] [F] [ENTER], the following menu appears:




The calculator is in alpha lock mode. Enter a file name (up to 14 characters) and press [ALPHA] [ENTER] to save the file. You can save up to 99 (10 for EL-9200) equations.

DEL deletes a file. (Files are displayed as in LOAD mode). Press G, select the file you want to delete, and press [ENTER]. A warning message similar to the following appears:




Press [ENTER] to confirm the deletion, or press [QUIT] to cancel.

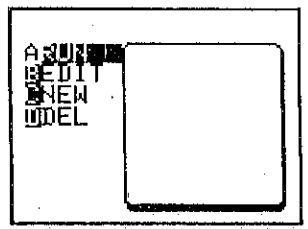
# CHAPTER 5:
# Programming

You can program your calculator to automate simple or complex calculations. Each program can use one of five modes: REAL, NBASE, MATRIX, COMPLEX, or STAT. Programs in REAL mode can draw graphs and access statistical variables. Programs in NBASE mode can perform logical operations and do calculations using hexadecimal, decimal, octal, or binary numbers. Programs in MATRIX mode have matrix functions enabled and programs in COMPLEX mode have complex functions enabled. Programs in STAT mode can use the statistic functions and draw statistical graphs.

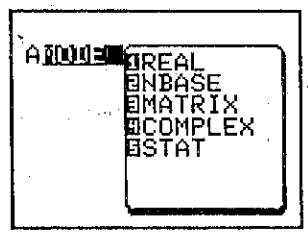
## Creating a new program

Follow this general procedure to create a new program:

1. Press [PRGM] to bring up the program menu. Any existing programs appear on the right side of the screen.




2. Press [C] [ENTER] and select the mode you want the program to run in.



3. Name the program and press [ALPHA] [ENTER].
4. Enter program commands. You can enter the calculator's regular functions as commands plus additional programming commands found under [2ndF] [COMMAND]. The commands available in this menu depend on the mode.

For examples of several programs, see the section titled *"Example Programs."*

# About programming

This manual does not cover all of the concepts behind writing programs. The information here is intended to help you apply your previous programming experience (in BASIC, FORTRAN, or another language) to writing programs on your calculator. The calculator programming language has similar elements to many programming languages.

All computer and calculator programs include one or more of the following fundamental elements:

- Input
- Conditional branching
- Looping
- Computation
- Output

Your calculator has programming commands that allow you to incorporate all of these fundamental elements into your programs. For a list of commands, see the section called *"Programming commands."*

Notes: Commands must be selected with shift command, not typed in manually with alpha mode.
Only one space should be used between commands and variables.





Although there are many commands, it is possible to program the calculator without using any of the program commands.

Example: Write a program that asks you the base and height of a triangle and then calculates and prints the area.

Press: [PRGM] [C] [ENTER] [1]
(The calculator automatically enters alpha mode for you to enter the title.)
Press: t r i [ALPHA] [ENTER]
[2ndF] [A·LOCK] area= [ALPHA] [(] 1 [÷] 2 [)] [2ndF] [A·LOCK] base [ALPHA] [x] [2ndF] [A·LOCK] height [ALPHA] [ENTER]

Now run the program:

Press: [MENU] [A]

Select the program called "tri" with the cursor keys and press [ENTER].

base=?
Press: 4 [ENTER]
height=?
Press: 4 [ENTER]
Result: area= 8.
Press: [CL] or [QUIT] to end, or press [ENTER] to begin the program again.

As shown above, the calculator automatically prompts you for unknown local variables. For more information, see the section below called *"About variables."*

# Typing and editing programs

It takes just a little practice to become proficient at typing programs on your calculator. Here are a few reminders and suggestions to help you speed up program entry:

- Whenever you want to add lines to your program, press [2ndF] [INS] first to avoid deleting lines or text you want to keep.
- As you learned in Chapter 1, the [ALPHA] key lets you use the alpha functions on the calculator. Use [2ndF] [A·LOCK] to lock the calculator in

alpha mode when you want to enter long strings of characters into your programs. Press [ALPHA] to turn off the lock.

- In alpha mode, pressing one of the keys with a letter enters a lowercase character. Press [2ndF] to get uppercase characters. Read the section *"About variables"* below to learn the difference between using lowercase and uppercase characters in your programs. There is no way to lock the calculator into uppercase only.
- Except for certain special cases, you can only have one command per line.
- A programming line can hold 160 (128 for EL-9200) characters. All commands count as one character. As you work on a line, it scrolls from left to right in the display. Programming lines do not wrap in the display.
- When running a program, text displayed by the program (using the Print command) will wrap in the display if necessary.
- The line you are working on does not change in the program until you press [▼] or [ENTER]. This feature allows you to quickly undo changes you make to a program line by pressing [QUIT] [ENTER] [ENTER]. However, **if you want to save changes you made to the current line, don't forget to press [▼] before quitting.**
- Blank lines entered between lines of a program are ignored.
- To clear an entire line of the program, press [CL]. You should quickly learn the difference between the [CL] key and the [BS] key. [BS] is useful for correcting typing mistakes.
- To delete an entire program, press [2ndF] [CA].
- Copy or move a program with the option menu, see Chapter 2 for more details.
- Change the name of a program by using the cursor keys and [ALPHA].





# About variables

In program mode, the case of your variables makes a difference:

- Single uppercase letters (A to Z and θ) are global variables. Global variables correspond to the memories of the calculator. (For example, C in a program means memory C of the calculator.) Global variables allow your programs to use values stored in memories, or to pass variables from one program to another. Global variables also allow you to store results from programs to use in any mode.
- Lowercase letters, lowercase numbers ([2ndF] *number*), and lowercase words are local variables. (For example, you may choose to use c in a program as a local variable.) Local variables exist only while the program exists. Local variables can be 12 letters or less.
- Uppercase and lowercase letters cannot be mixed to form one variable. The single uppercase letters will always be taken as a single variable.

Here's some examples of how you may use variables in a program:

1. X = 5: This program line sets the program variable X equal to 5. It also stores 5 in the X memory.
2. heat = 9.22: This program line sets the program variable "heat" equal to 9.22. When the program ends, this variable will be stored in local variables.
3. Y = mX+b: sets Y equal to (m * X) + b. If m and b are not defined earlier in the program, the calculator prompts you with m=? and b=? to define these two variables. The program takes the value for X from its own X memory.

Turn the above equation (Y = mX+b) into a program.

**Example:** Program the equation Y = mX+b.

Press: [PRGM] 4.4 [STO] X [PRGM] [C] [ENTER] [↓]
s l o p e [ALPHA] [ENTER]
[2ndF] [A·LOCK] [2ndF] Y = m [2ndF] X [ALPHA] [+] [ALPHA]
b [▼]

Now run the program:

Press: [QUIT] [A]
Select the program named "slope"
[ENTER]
m=?
Press: 5 [ENTER]
b=?
Press: 7 [ENTER]
Y=29.

The answer depends on what you have stored in the X memory. The calculator prompts you for the lowercase letters m and b, but not for X.

The previous example shows you two ways your programs can receive input. Using an undefined local variable in a program causes it to ask for input. Using a global variable causes the program to take input from memory. Another way programs can receive input is to use the Input command listed below.

# Programming commands

This section describes all the available commands in program mode. The commands are listed alphabetically. The list does not include available keyboard commands or [MATH] menu commands.

Unless otherwise noted, the programming commands are available in all program modes.

**Auto** *<graph command>* [2ndF] [COMMAND] D2
(available in REAL and STAT programs only)

Selects a Y range and then performs the graph command. The graph command can be Graph, DotGraph, Fill, or any of the statistical graph commands.

Examples: Auto Graph sin X, cos X, tan X
Auto G(HIST)





**ClrG** [2ndF] [COMMAND] E2
Clears the Graph Screen, without affecting any text or changing display modes.

Example: ClrG

**ClrT** [2ndF] [COMMAND] E1
Clears the Text Screen, without affecting any drawn graphs or changing display modes.

Example: ClrT

**Data** *<x> {,y} {,w}* [2ndF] [COMMAND] F5
(available in STAT programs only)
Enters a new statistical data point in the next available card. The arguments must be consistent with the statistics mode selected (one-variable or two-variable, weighted or not weighted). The statistical data set can be accessed later in statistics mode.

Examples: Data 5.23
Data 25,2
Data 72,175
Data 9,96,3

**DispG** [2ndF] [COMMAND] E4
Shows the Graph screen.

Example: DispG

**DispT** [2ndF] [COMMAND] E3
Shows the Text Screen.

Example: DispT

**DotGraph** *<func1> {,func2} {,func3} {,func4}* [2ndF] [COMMAND] D3
(available in REAL programs only)
Same as the Graph command except that it draws non-connected dot graphs. (This command does not change the setting in graph mode.)

Example: DotGraph sin X, cos X, tan X

**End**

2ndF COMMAND A6

Marks the end of a program. End is not required to end a program. If there is no end statement, the calculator will display the last calculated answer upon completion of the program. End does not need to be at the end of a program, and there can be more than one end command in a program (for example, to end different subroutines).

Example: End

**Fill** *<func1> <,func2>*

2ndF COMMAND D8

(available in REAL programs only)

Draws a graph and fills the space (if any) below function 1 and above function 2.

Example: Fill sin X, cos X

**G(B.C.)**

2ndF COMMAND G6

(available in STAT programs only)

Draws a box chart from the current statistical data. Statistics mode must be XY or XYW. The maximum number of boxes that can be displayed is 11.

Example: G(B.C.)

**G(B.L.)**

2ndF COMMAND G2

(available in STAT programs only)

Draws a broken line chart from the current statistical data. The maximum number of data points that can be displayed is 31.

Example: G(B.L.)

**G(C.F.)**

2ndF COMMAND G3

(available in STAT programs only)

Draws a cumulative frequency chart from the current statistical data. The maximum number of data points that can be displayed is 31.

Example: G(C.F.)





**G(exp)**

2ndF COMMAND H2

(available in STAT programs only)

Draws the best fit exponential regression curve from the current statistical data. Statistics mode must be XY or XYW.

Example: G(exp)

**G(HIST)**

2ndF COMMAND G1

(available in STAT programs only)

Draws a histogram from the current statistical data. The maximum number of data points that can be displayed is 31.

Example: G(HIST)

**G(inv)**

2ndF COMMAND H6

(available in STAT programs only)

Draws the best fit inverse regression curve from the current statistical data. Statistics mode must be XY or XYW.

Example: G(inv)

**G(line)**

2ndF COMMAND H1

(available in STAT programs only)

Draws the best fit linear regression line from the current statistical data. Statistics mode must be XY or XYW.

Example: G(line)

**G(ln)**

2ndF COMMAND H3

(available in STAT programs only)

Draws the best fit natural logarithmic regression curve from the current statistical data. Statistics mode must be XY or XYW.

Example: G(ln)

**G(log)**

2ndF COMMAND H4

(available in STAT programs only)

Draws the best fit logarithmic regression curve from the current statistical data. Statistics mode must be XY or XYW.

Example: G(log)

**G(N.D.)**
(available in STAT programs only) 2ndF COMMAND G4
Draws a normal distribution curve from the current statistical data.

Example: G(N.D.)

**G(pow)**
(available in STAT programs only) 2ndF COMMAND H5
Draws the best fit power regression curve from the current statistical data. Statistics mode must be XY or XYW.

Example: G(pow)

**G(S.D.)**
(available in STAT programs only) 2ndF COMMAND G5
Draws a scatter diagram from the current statistical data. Statistics mode must be XY or XYW.

Example: G(S.D.)

**Gosub** *<anytext>* 2ndF COMMAND B4
Calls the subroutine beginning with Label *<anytext>*. A Gosub statement must have a matching Label to mark the beginning of the subroutine, and a Return command to mark the end of the subroutine. Subroutines can be nested up to ten levels deep.

Example: Gosub part1

**Goto** *<anytext>* 2ndF COMMAND B2
Jumps program execution to Label *<anytext>*.

Example: Goto loop

**Graph** *<func1> [,func2] [,func3] [,func4]* 2ndF COMMAND D1
(available in REAL programs only)
Graphs up to four functions. Commas must be used to separate the functions. The graphs are drawn sequentially or simultaneously according to the setting in Graph mode.

Examples: Graph sin X, cos X, tan X
Graph 3X^2-2X + 6





**If** *<conditional expression>* **Goto** *<anytext>* 2ndF COMMAND B3 2ndF COMMAND B2
Conditional branches begin with an If command (B3), followed by a conditional expression, and then a Goto command (B2). **Goto is the only command that can follow an If statement.** You can place a space (ALPHA SPACE) before the Goto command to improve the readability.

Example: If apple=1 Goto loop

**Inequalities** 2ndF COMMAND C1 to C6
Forms the conditional expressions used with **If** and **Goto**. The inequalities are the basis for looping and conditional branching in your programs. The inequalities are:

| | | |
|---|---|---|
| 2ndF COMMAND C 1 | = | Equal to (Same as ALPHA =) |
| 2ndF COMMAND C 2 | < | Less than |
| 2ndF COMMAND C 3 | <= | Less than or equal to |
| 2ndF COMMAND C 4 | >= | Greater than or equal to |
| 2ndF COMMAND C 5 | > | Greater than |
| 2ndF COMMAND C 6 | ≠ | Not equal to |

Examples: If X<0 Goto neg
If z=3 Goto ratecalc
In the above examples, "neg" and "ratecalc" are labels.

**Input** *<variable>* 2ndF COMMAND A3
Stops the program and prompts you with "*<variable>*=?" to enter a value for *<variable>*.

Examples: Input A.
Input apple
Input A[1,1]

In the above examples, A is a global variable and apple is a local variable. A[1,1] is a matrix element.

**Label** *<anytext>*
2ndF COMMAND B1
Marks a destination point for a branch statement (such as Goto). Each label must be unique (you can't enter the same label more than once in the same program) and must be ten (eight for EL-9200) characters or less. The label can be used 50 pcs. or less (12 pcs. or less for EL-9200) in each program.

Example: Label loop

**Line** $<x_1>$, $<y_1>$, $<x_2>$, $<y_2>$
(REAL and STAT programs only) 2ndF COMMAND D7
Draws a line between points $x_1,y_1$ and $x_2,y_2$.

Example: Line 180,1,-180,1

**Plot** <x>, <y>
(available in REAL and STAT programs only) 2ndF COMMAND D6
Plots a point at coordinates x,y.

Example: Plot 180,1

**Print** "*<any text>* 2ndF COMMAND A1 2ndF COMMAND A2
Prints the text listed after the quotation mark. There is no limit to the length of a text string except the 160 (128 for EL-9200) characters line limit. However, only 128 characters fit on the display.

Example: Print "Hello world

**Print** *<variable>*
Prints the value of *<variable>*. The display format is determined by the SET UP menu. 2ndF COMMAND A1

Examples: Print A
Print apple
Print A[1,1]

In the above examples, A is the value currently stored in memory A, and apple is a local variable. A[1,1] is a matrix element.





**Range** *<xmin>, <xmax>, <xscale>, <ymin>, <ymax>, <yscale> {,n}*
(available in REAL and STAT programs only) 2ndF COMMAND D4
Sets the range for the graphing screen. The y range is required even if the Auto Graph function is used to plot the curve. The n value is the number of segments for statistical graphs.

Example: Range -360,360,90,-1.2,1.2,0.5

**Rem** *<any text>* 2ndF COMMAND A5
Inserts a remark statement. This line has no effect on the program operation. It allows you to document your programs. Excessive use of this command will use up extra memory.

Example: Rem Temperature-Pressure conversion

**Return** 2ndF COMMAND B5
Ends a subroutine and resumes program operation at the line following the Gosub statement that called the subroutine.

Example: Return

**St[<1, 2, or 3>, <n>]**
(available in STAT programs only) 2ndF COMMAND F6
Recalls or stores a value in an existing statistics card. The first variable specifies x, y, or w, and the second variable specifies the data card number. The square parentheses are required in the syntax (2ndF COMMAND F7 and 2ndF COMMAND F8) and are available from the same command menu. Use this statement consistently with the statistics mode selected (one-variable or two-variable, weighted or not weighted), or you will get an error.

| | |
|---|---|
| one-variable | 1 is the x-value |
| one variable with weight | 1 is the x-value<br>2 is the weight |
| two variable | 1 is the x-value<br>2 is the y-value |
| two variables with weight | 1 is the x-value<br>2 is the y-value<br>3 is the weight |

Examples: St [1,234]
St [3,14]=3

The first example recalls the x-value of card 234. The second example sets the weight of card 14 to 3.

**Stat X**
(available in STAT programs only) 2ndF COMMAND F1
Selects one-variable statistics mode.

Note: This command erases all of the data stored on the statistics cards.
Example: Stat X





**Stat XW**
(available in STAT programs only) 2ndF COMMAND F2
Selects weighted one-variable statistics mode.

Note: This command erases all of the data stored on the statistics cards.
Example: Stat XW

**Stat XY**
(available in STAT programs only) 2ndF COMMAND F3
Selects two-variable statistics mode.

Note: This command erases all of the data stored on the statistics cards.
Example: Stat XY

**Stat XYW**
(available in STAT programs only) 2ndF COMMAND F4
Selects weighted two-variable statistics mode.

Note: This command erases all of the data stored on the statistics cards.
Example: Stat XYW

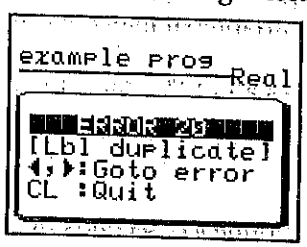
**Wait *(number)***
2ndF COMMAND A4
Pauses the program for *(number)* seconds or until you press a key. The maximum number of seconds is 255. If you don't specify a wait time, then the program pauses until you press a key. The BUSY indicator stays on while the program is waiting. Wait is useful for displaying intermediate results and other information.
Example: Wait 5

**Zoom** *<n> {,yn}* 2ndF COMMAND D5
(available in REAL and STAT programs only)
Zoom adjusts the range by a factor of 1/n. If two values are used, then the first value adjusts the X range, and the second value adjusts the Y range. The scale settings are not adjusted by the zoom command. You must draw a graph before you zoom.

Examples: Zoom 2
Zoom 1,5

# Error Messages

After entering a program, it's often necessary to debug it. To make this task easier, the calculator displays an error message if it has a problem running your program. For example, if you have more than one label with the same name in your program, you see the following message:




To see the faulty line, press ◀ or ▶. To return to the program menu, press CL.

At any time while running your program you can press ON to stop it. This would be necessary if your program has entered an endless looping sequence. Then press ◀ or ▶; the cursor appears at the last line your program executed.

For a list of error messages, see Appendix B.





# Example programs

Try running these examples to get some experience programming the calculator. They demonstrate different programming modes, program input, program output, looping, and conditional branching.

## Some like it hot (Real mode)

Suppose you need to convert temperatures from Celsius to Fahrenheit and vice versa. You could do this using calculation mode or using the EL-9300's solver mode. A third way would be to create a program as follows:

1. Press PRGM to select program mode. Press C ENTER 1 to create a new REAL mode program.
2. Name the program `temp conv` and press ALPHA ENTER.
3. Enter the following program lines:

```
Label start
Print "1 C to F
Print "2 F to C
Input choice
If choice=1 Goto ctof
If choice=2 Goto ftoc
Goto start
Label ctof
Input c
f=(9/5)*c+32
Print f
End
Label ftoc
Input f
c=(5/9)*(f-32)
Print c
End
```

4. Now try running the program. Press [QUIT], [A], select the program, and press [ENTER]. The program prompts you to choose the type of conversion you want, prompts you to enter the temperature, and displays the results.

## 2B OR NOT 2B (Nbase mode)

When you write a program in Nbase mode, the conversion functions and logical operations are enabled. Write a simple program that converts a decimal number to binary, octal, and hexadecimal as follows:

1. Press [PRGM] [C] [ENTER] [2] to create a new NBASE mode program.
2. Name the program `dec conv` and press [ALPHA] [ENTER].
3. Enter the following program lines:

```
Print "Enter a decimal
Input X
X→bin                (Press [MATH] [D] [4] to enter the →bin command.)
binary=X
Print binary
X→oct
octal=X
Print octal
X→hex
hexadecimal=X
Print hexadecimal
```

   Notice that the program transfers the value of X to the variables binary, octal, and hexadecimal before printing. This is done so that the display is labeled properly.

4. Now try running the program. Press [QUIT], [A], select the program, and press [ENTER]. The program prompts you to enter a decimal and returns the three conversions.
5. Note that you will get an error if you try to convert a number larger than 32767 to binary. For more practice, add a conditional branch to your program that skips binary conversion if x>32767.





## 2 x 4 (Matrix mode)

When you write a program in matrix mode, all of the matrix functions are available. Suppose you wanted to fill a *n* by *m* matrix with random numbers between 0 and 1. You would need to use the random number function and two nested loops as shown in the following example.

1. Press [PRGM] [C] [ENTER] [3] to create a new MATRIX mode program.
2. Name the program `mat fill` and press [ALPHA] [ENTER].
3. Enter the following program lines:

```
dim A[n,m]           (Press [MATH] [E] to find the dim, [, and ] commands.)
i=1
Lbl filli
j=1
Lbl fillj
A[i,j]=rand          (Press [MATH] [A] [8] to enter the rand command.)
j=j+1
If j<=m Goto fillj
i=i+1
If i<=n Goto filli
End
```

4. Now try running the program. Press [QUIT], [A], select the program, and press [ENTER].
5. To see the filled matrix, press [QUIT] [▦] [MENU] [A] [3] [MENU] [B] 01. Scroll through the matrix and note that all of the entries are numbers between 0 and 1.

## Do you have a complex? (Complex mode)

Write a program the asks for a complex number as input, then tells you real portion, the imaginary portion, the argument, and the complex conjugate of the complex number.

1. Press [PRGM] [C] [ENTER] [4] to create a new COMPLEX mode program.
2. Name the program X+Yi and press [ALPHA] [ENTER].
3. Enter the following program lines:

```
real^w/r P=real number (Press [MATH] [E] to find the complex functions.)
imagin=image number
argmt=arg number
conjgt=conj number
Print realP
Print imagin
Print argmt
Print conjgt
End
```

4. Now try running the program. Press [QUIT], [A], select the program, and press [ENTER].
5. The program asks you for a number, and then prints all of the data.





## The top ten (STAT mode)

Write a simple program that asks for ten test scores and graphs a histogram of the data, as follows:

1. Press [PRGM] [C] [ENTER] [5] to create a new STAT mode program.
2. Name the program grader and press [ALPHA] [ENTER].
3. Enter the following program lines:

```
Gosub inscore
Gosub avgscore
Gosub grscore
End

Label inscore
Stat X
Print "Enter scores
i=1
Label iloop
Input X
Data X
i=i+1
If i<=10 Goto iloop
Return

Label avgscore
Print "Average score is
X=x̄        (Press [MATH] [E] [1] to enter the x average, x̄.)
Print X
Wait 5
Return

Label grscore
Range 0,100,10,0,10,1,10
G(HIST)
Return
```

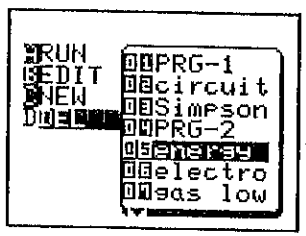
When you run the program, the test scores must be between 0 and 100 (if you want to see them all).

## Deleting programs

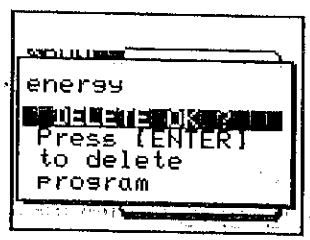
You can have up to 99 (51 for EL-9200) programs. To clear space for new programs, delete the old ones.

Delete a program as follows:

1. Press [PRGM] to select program mode.
2. Press [D] to select the delete function.




3. Enter the number of the program you want to delete or select it using the cursor keys and press [ENTER].




4. The calculator asks if you want to delete the program. Press [ENTER] to delete the program.

Note: A quick way to delete a program while editing is to press [2ndF] [CA]. The above warning message appears. Press [ENTER] to delete the program.



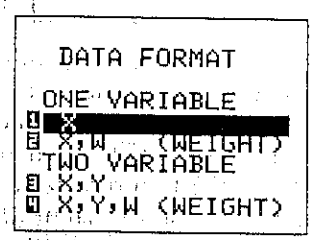
# CHAPTER 6: Using Statistics

Your calculator can perform one- and two-variable weighted statistics calculations.

Normal calculator functions are also available in statistics mode, and statistical results can be used in calculations or programs.

## Selecting statistics mode

To select statistics mode, press [STAT]. If there isn't any statistics data, the following menu is displayed:

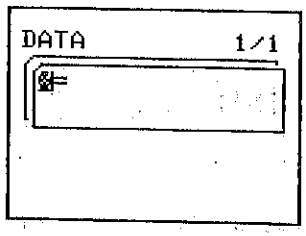



Select one of the four formats: one variable (X), one variable with weight (X,W), two variables (X,Y), and two variables with weight (X,Y,W).

# One-variable statistics

Note: You must delete all statistics data to enter a new statistics data format. See the section below called *"Deleting data."* If you want to save your data, see *"Transferring data to a matrix."*

Press [2nd] [1] to select one-variable statistics, and the first "card" of data appears.




Each card contains one data value (often called an *observation* by statisticians). Use the keypad to enter the data values. After pressing [ENTER] the calculator displays the next card (the next data value). To display the previous data value, press [◀]. To display the next data value press [▶]. Use [2ndF] [◀] or [2ndF] [▶] to jump to the first or last card. The *card/count* number is displayed at the top right of the card. For example, 2/5 means that the second of five cards is currently displayed.

**Example:** What is the mean of the following test scores: 75, 85, 90, 82, and 77?

Press: [2nd] [1] 75 [ENTER] 85 [ENTER] 90 [ENTER] 82 [ENTER] 77 [ENTER]

Press: [MENU] [A] [1]

Result:

```
x̄  =          81.8
sx = 6.058052492
σx = 5.418486874
Σx =          409.
Σx²=        33603.
n  =            5.
xmi=           75.
xma=           90.
```

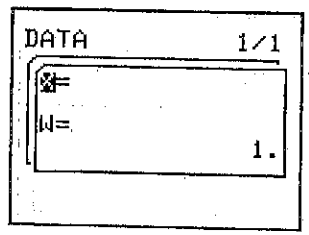
If you don't know what the results mean, see *"The statistics menu,"* below.





## One-variable with weight

If your sample data contains a value that is repeated a number of times, enter it as a weighted variable. For example, entering a variable with a weight of 5 is the same as entering the value five times. Weighted one-variable data cards look like this:




Key-in the x value, press [ENTER], and enter the weight.

**Example:** What is the mean of the following test scores: 75, 75, 75, 75, 90, 90, 77.

Press: [2nd] [MENU] [D] [2] [ENTER] Deletes any previous data.

Press: [2] Selects one-variable with weight.

75 [ENTER] 4 [ENTER] 90 [ENTER] 2 [ENTER] 77 [ENTER]

[MENU] [A] [1]

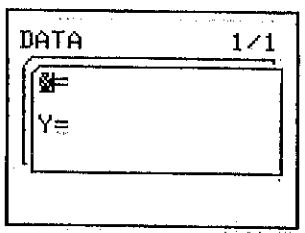
Result:

```
x̄  =          80.
sx = 7.745966692
σx = 7.071067812
Σx =          480.
Σx²=        38700.
n  =            6.
xmi=           75.
xma=           90.
```

If no weight is entered, w is automatically set to 1.

# Two-variable statistics

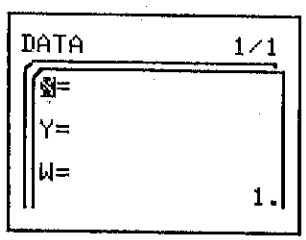
Entering data for two-variable statistics is similar to one-variable statistics, except that data points are identified as a pair (x,y). After selecting [≡], delete any previous data ([MENU] [D] [2] [ENTER]) and press [3]. The first card of data appears:




Key-in x, press [ENTER], and key-in y. Pressing [ENTER] automatically moves you to the next card so you can enter the next data pair. Use [◄] and [►] to move between cards.

## Two-variables with weight

If your sample data contains pairs that are repeated a number of times, enter it as weighted two-variable statistics. For example, entering one data pair with a weight of 10 is the same as entering the data pair ten times. After selecting [≡] delete any previous data ([MENU] [D] [2] [ENTER]) and press [4], the first card of data appears:




Use the keypad to enter the x value, press [ENTER], enter the y value, press [ENTER], and enter the weight. Use the [◄] and [►] keys to move between cards.





**Example:** Find the mean of the following 30 math and physics test scores: 10 at (80,75), 15 at (90,80), 4 at (90,90), and 1 at (95,90).

Press: [≡] [MENU] [D] [2] [ENTER] [4]

(Deletes any old data and enters two-variables with weight mode.)

Press: 80 [ENTER] 75 [ENTER] 10 [ENTER] 90 [ENTER] 80 [ENTER] 15 [ENTER] 90 [ENTER] 90 [ENTER] 4 [ENTER] 95 [ENTER] 90 [ENTER] [ENTER]

[MENU] [A] [1] (The math test statistics)

Result:

```
x̄  = 86.83333333
sx = 4.997125611
σx = 4.913134324
Σx =        2605.
Σx²=      226925.
n  =          30.
xmi=          80.
xma=          95.
```

Press: [MENU] [2] (The physics test statistics)

Result:

```
ȳ  =          80.
sy = 5.085476277
σy =           5.
Σy =        2400.
Σy²=      192750.
Σxy=      208950.
ymi=          75.
yma=          90.
```

If no weight is entered, w is automatically set to 1.

# Entering data

When entering statistical data you can enter numbers, variables or equations, but only the result is stored. If you make a mistake while entering data press [CL] (before you press [ENTER]) and the previous entry will be returned. [2ndF] [CA] deletes an entire card.

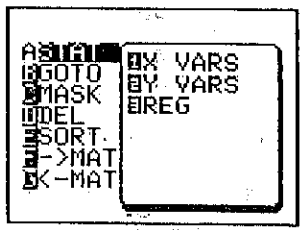
You may enter up to 999 (EL-9200: 199 for single-variable and 99 for two-variable) data cards or observations.

# The statistics menu

The [MENU] key lets you view statistical results, move through the data cards, mask, delete, or sort data, and store or retrieve data in matrices.

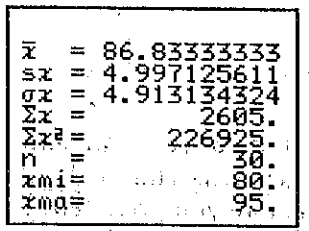
## Statistical results

After entering the data, view statistical results by pressing [MENU] [A], and the following menu is displayed:




### X VARS

D X VARS shows the x statistics. Assuming you completed the previous example, selecting X VARS displays the following statistical results:




Where:

$\bar{x}$ is the average or mean value of the data.





sx is the sample standard deviation.[7] Sample standard deviation assumes the data is a sample from a population.

σx is the population standard deviation.[8] Population standard deviation assumes that the data represents the entire population.

Σx is the sum of the x data values.

$\Sigma x^2$ is the sum of the squares of the x data values.

n is the number of data values entered (the number of observations or cards).

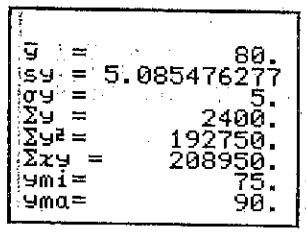
xmi is the minimum value of x.

xma is the maximum value of x.

### Y VARS

E Y VARS is available only when two-variable data has been entered.

Y VARS shows the y statistics. If you just completed the previous example using two-variable observations, Y VARS displays the following statistical results:




Where:

$\bar{y}$ is the average or mean value of the y-data values.

---

[7] $sx = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n-1}}$ $\quad sy = \sqrt{\frac{\Sigma y^2 - n\bar{y}^2}{n-1}}$

[8] $\sigma x = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n}}$ $\quad \sigma y = \sqrt{\frac{\Sigma y^2 - n\bar{y}^2}{n}}$

sy is the standard deviation when the y-values constitute a sample chosen from a population[7].

σy is the standard deviation when the y-values form a population.

Σy is the sum of the y-data values.

Σy² is the sum of the squared y-data points.

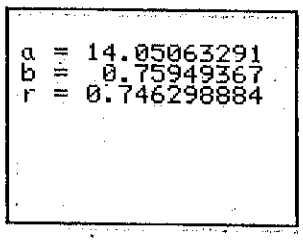
Σxy is the sum of the x-data values multiplied by their corresponding y-data values.

ymi is the minimum value of y.

yma is the maximum value of y.

## Regression

REG shows regression data. This option is available only when two-variable data has been entered. A model for the relationship between an expected value of a variable and the value of a related variable is called a regression. If you select REG from the variable menu, the following linear regression results are displayed:




Where:

a is the first regression coefficient, that is, the y-intercept of the linear regression equation y=a+bx.

b is the slope of the regression line.

r is the correlation coefficient.

(You can graph other types of regression equations and view their regression coefficients, see *"Graphing statistics"* in the next chapter.)

Regression equations have three important values: a, b, and r.





The correlation coefficient shows the quantitative relationship between x and y for a particular sample. It measures how well the regression line fits the data points.

The value of r is between -1 and 1. If r equals -1 or 1, all points on the correlation diagram are on a straight line.

The further the value of r is from -1 or 1, the fewer the number of points will be found massing about the line. The closer the value of r is to 0, the less reliable the correlation. If r is more than 0, it shows a positive correlation (as x increases, y increases); if r is less than 0, it shows a negative correlation (as x increases, y decreases).

**Example:** How dependent is a person's weight on their height? Determine the regression equation for the following ten people. Here is the data (in centimeters and kilograms):

| | | |
|---|---|---|
| 1 | 186 | 84 |
| 2 | 184.8 | 79.5 |
| 3 | 165 | 65.9 |
| 4 | 180 | 77.2 |
| 5 | 177 | 80.5 |
| 6 | 172.5 | 70.5 |
| 7 | 180 | 65 |
| 8 | 172.2 | 55 |
| 9 | 186 | 81.8 |
| 10 | 169.5 | 62 |

Enter statistics mode, clear any previous data, and enter the above data.

Press: [≡] [MENU] [D] [2] [ENTER] [3]
(Deletes all data and selects two-variable data mode.)
Press: 186 [ENTER] 84 [ENTER] 184.8 [ENTER] 79.5 [ENTER]
(This enters the first two pairs) continue entering the remaining pairs.
After entering the data, review it using the cursor keys to make sure it was entered correctly.

View the regression coefficients by pressing [MENU] A 3. The results are:

a= -105.8750968
b= 1.004033259
r= 0.747255362

Therefore the linear regression equation is y=-105.87+1.00x.

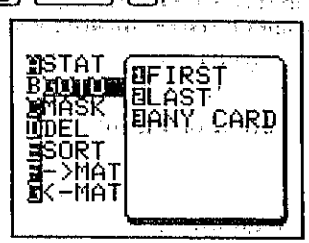
In calculation mode, you can use the x' and y' functions to estimate values for x and y, and you can use all of the statistical results presented above in equations and programs.

| | | |
|---|---|---|
| Example: | After completing the previous example determine the expected weight of a man 183 centimeters tall. What is the expected height of a 60 kilogram man? | |
| Press: | [▦] [MENU] [1] 183 [MATH] [G] [5] | |
| Result: | 77.86298958 | The 183 centimeter man weighs about 78 kilograms. |
| Press: | 60 [MATH] [G] [4] | |
| Result: | 165.2087671 | The 60 kilogram man is a little over 165 centimeters. |

Note: Statistics mode and calculation mode regression values are always based on linear regression, even if another type of regression is selected in statistic graph mode.

## Moving through the data

Besides using [◄] and [►] to page through the cards, you can use the statistics menu to move to the first, the last, or a designated card by pressing [MENU]. Press [▤] [MENU] [B], and the following menu appears:




A FIRST moves you to the first data card. (same as [2ndF] [◄])

B LAST moves you to the last data card. (same as [2ndF] [►])



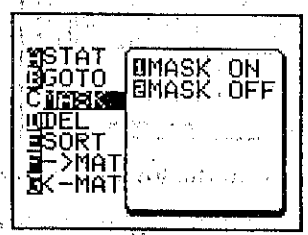


C ANY CARD asks you to enter a card number. Enter the number of the card you want to see. If you enter a number greater than the last card number, the last card appears.

## Masking unwanted data

You can exclude, or mask, unwanted or unusual values from the statistic calculations, while retaining them as input data.

Recall the card you want to mask or unmask on the screen. Press [MENU] [C] and the following menu is displayed:




A MASK ON excludes the current data card from the statistics calculations.

B MASK OFF includes the current card in the statistics calculations.

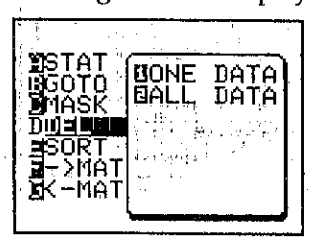
When a card is masked an [M] appears at the top of th

## Deleting data

You can delete a single card or all of the data cards.

To delete a single card, you must go to the card you want to delete.

Press [MENU] [D] and the following menu is displayed:



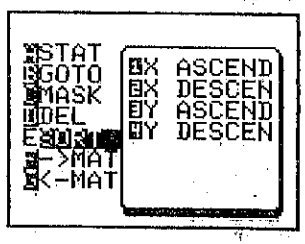

A ONE DATA deletes the selected card.

ALL DATA deletes all of the cards. You will be asked to confirm this selection, if you want to delete all of the cards, press [ENTER].

## Sorting data

You can sort the data cards in four different ways.

Press [MENU] [E] and the following menu is displayed:




X ASCEND sorts the cards from the lowest x value to the highest.

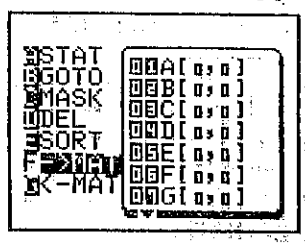
X DESCEN sorts the cards from the highest x value to the lowest.

Y ASCEND sorts the cards from the lowest y value to the highest. This function is not available in one-variable format.

Y DESCEN sorts the cards from the highest y value to the lowest. This function is not available in one-variable format.

## Transferring data to a matrix

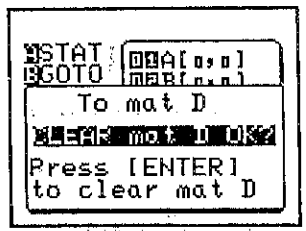
To transfer the data that has been entered on cards in statistic mode to a matrix, press [MENU] [F]. The following menu appears:








Select a destination matrix. (Matrices with [0,0] listed as their dimensions are empty.) If the selected matrix is not empty, you will get a warning message:




Press [ENTER] if you want to replace the contents of the matrix with the contents of the data cards.

The new dimensions of the matrix are displayed in the matrix list. The number of columns the new matrix has depends on the number of cards. Each data card is considered one column of the matrix. The new matrix can have up to three rows. The x values are considered the first row, the y values are the second row (or the weights for one-variable with weight), and the weight values are the third row. For example, if the data cards contained the following information: card 1: x=1, y=10; card 2: x=2, y=20; card 3: x=3, y=30; card 4: x=4, y=40, then the new matrix is:

$$\begin{vmatrix} 1 & 2 & 3 & 4 \\ 10 & 20 & 30 & 40 \end{vmatrix}$$

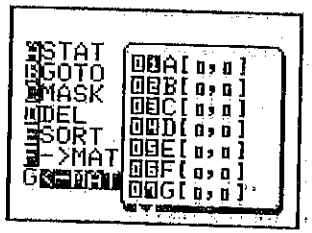
The following is a list of the statistics modes and the way data is stored in matrices:

| | |
|---|---|
| one-variable: | row 1 contains the x-data |
| one variable with weight: | row 1 contains the x-data<br>row 2 contains the weights |
| two variable: | row 1 contains the x-data<br>row 2 contains the y-data |
| two variables with weight: | row 1 contains the x-data<br>row 2 contains the y-data<br>row 3 contains the weights |

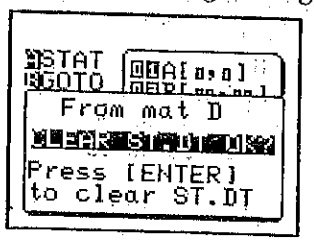
After data has been transferred to a matrix, all of the matrix functions and row operations are available. The matrix can be altered and then transferred back to the statistic cards for further analysis.

## Transferring data from a matrix

To transfer data that has been entered in a matrix to data cards in statistic mode, press [MENU] [G], the following menu appears:




Select a source matrix. The matrix dimensions must be [1,x], [2,x], or [3,x]. [3,x] is weighted statistics, the third row contains the weights. If the data cards are not empty, you will get a warning message:



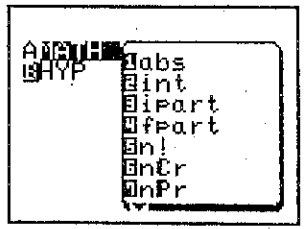

Press [ENTER] if you want to replace the contents of the data cards with the contents of the matrix.





# Math functions

All of the function keys are available in statistics mode, and other math functions are available from the [MATH] menu. Functions can be part of an equation that is being entered in a card. After [MATH] is pressed, the following display appears:




These functions are described in Chapter 3.

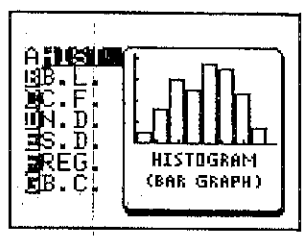
The 1HYP menu contains the hyperbolic trigonometric function described in Chapter 3.

# CHAPTER 7:
# Graphing Statistics

Your calculator can draw six different types of graphs, and plot six types of regression curves in statistics graph mode.

## Selecting statistics graph mode

To select statistics graph mode, press [2ndF] [graph]. The following menu is displayed:




This menu lets you select a graph type. You can also select some of the graph functions described in Chapter 4 (for example, [2ndF] [PLOT]).

Graphs can be drawn over each other for comparisons. Press [2ndF] [CA] to clear all previously drawn graphs.

## Graph types

The six different graph types are: histograms, broken-line graphs, cumulative frequency graphs, normal distributions, scatter diagrams, and box charts. The six types of regression are: Linear, exponential, logarithmic, logarithmic base 10, power, and inverse.

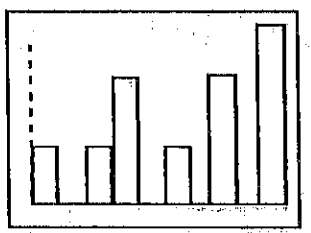
## Histograms

Histograms plot only x-values. The horizontal position of the bar is the x-value. The height of the bar is the number of times (or percentage) that a particular x-value occurs in the data.

**Example:** Plot the weight information of the last regression example in Chapter 6.

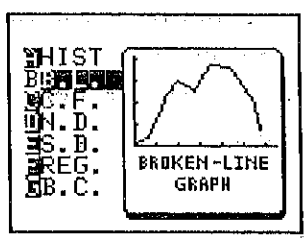
Press: [2ndF] [graph] [A] [2ndF] [AUTO]

Result:



## Broken-line graphs

B.L. draws a broken-line graph. Press [2ndF] [graph] [B] and the following menu appears:




Press [ENTER] to graph over the histogram.

Broken-line graphs plot only x-values. The horizontal position of a point is the x-value, the vertical position is the number of occurrences of that x-value.

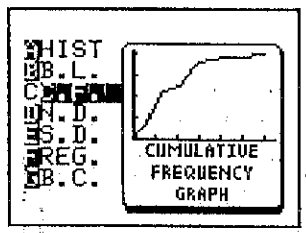
Note: To clear the graph screen, press [2ndF] [PLOT] [A] [ENTER].





## Cumulative frequency graphs

C.F. draws a cumulative frequency graph. Press [2ndF] [graph] [C] and the following menu appears:

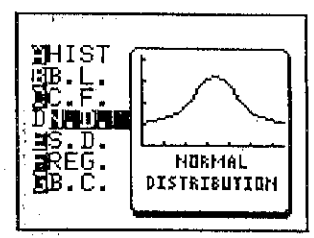



Press [2ndF] [AUTO] to graph the data.

Cumulative frequency graphs show the sum of the number of occurrences of the x-values.

## Normal distributions

N.D. draws a normal distribution. Press [2ndF] [graph] [D] and the following menu appears:




Press [2ndF] [AUTO] to graph the data.

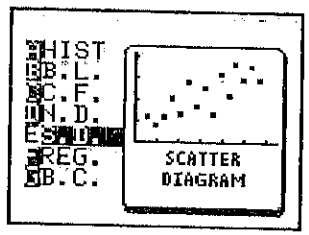
Normal distributions plot the relationship between the mean and the standard deviation of the x-values. The total area under a normal distribution is always equal to 1.

In all four of the above graph modes, you can move through the graphed data with [▶] and [◀]. As you move along the graphs, the x and y coordinates appear at the bottom of the screen. In histogram, broken-line

and cumulative frequency graphs, and Box charts the cursor is at the right edge of the graphed data, but the coordinates displayed refer to the left edge. To change the viewing window, refer to the [RANGE] key description below.

## Scatter diagrams

S.D. draws a scatter diagram. Press [2ndF] [graph] [E] and the following menu appears:

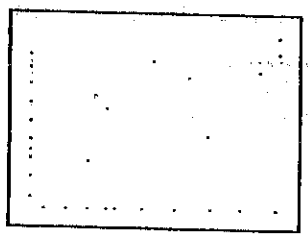



Scatter diagrams plot the x-values versus the y-values. Only two-variable data can be graphed.

**Example:** Plot the weight and height information in the regression example above.

Press: [2ndF] [graph] [E] [2ndF] [AUTO]

Result:



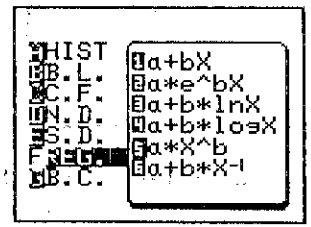
You cannot move through the scatter diagram with the cursor keys. If you want to see where the points lie, use the Plot FREE function described in Chapter 4.





## Regression graphs

REG. plots six different regression curves. Press [2ndF] [graph] [F] and the following menu appears:




The following regression curves can be graphed:

- Linear regression: a+bX
- Exponential regression: a*e^bX
- Logarithmic regression: a+b*lnX
- Log base 10 regression: a+b*logX
- Power regression: a*X^b
- Inverse regression a+b*X$^{-1}$

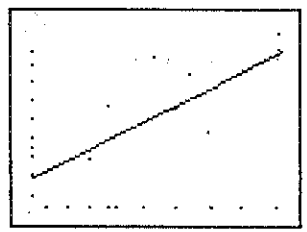
You can plot any or all of these curves on top of an existing graph.

**Example:** Plot linear and power regression curves on top of the previous scatter diagram.

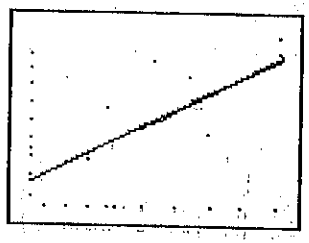
Do the previous example. While the scatter diagram is displayed,

Press: [QUIT] [F] [1]

Result:



Press: QUIT F 5
Result:

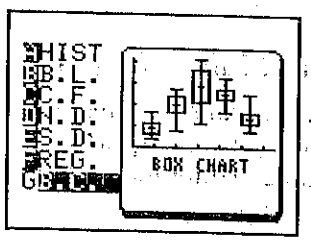


All of the regression curves will be similar through the data, however one curve is always closest to the actual data. You can compare the correlation coefficients to see which curve fits the data better. For more information see the section below called *"The statistics graph menu."*

You can move the cursor along the regression curve with ▶ and ◀. As you move along the curve, the x and y coordinates appear at the bottom of the screen.

## Box charts

B.C. draws a box chart. Press QUIT to exit the previous example. Press G and the following menu appears:

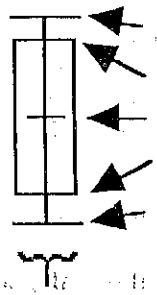



Box charts plot the minimum, the maximum, the mean, and the standard deviation of y-values around a specific x.





You can move through the box chart graph with ▶, ◀, ▼, ▲. As you move along the graph, the x and y coordinates appear at the bottom of the screen. You can move to the following points:




## The graph keys

The following six keys affect graphs: MENU EQTN QUIT RANGE ZOOM PLOT AUTO.

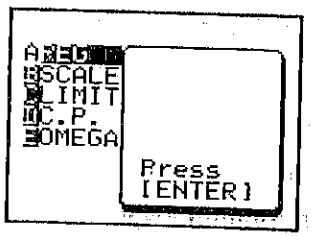
EQTN and QUIT return you to the statistics graph menu. Use them to exit the graph display and select a different type of graph function.

2ndF AUTO automatically scales the range. This is an easy way to quickly view graphs. 2ndF AUTO usually clears any old graphs, but if cumulative frequency (C.F.) or normal distribution (N.D.) are selected, they will be graphed over the existing data (even though the range has changed).

ZOOM and 2ndF PLOT perform the same functions described in Chapter 4.

## The statistics graph menu

Press [MENU] and the following menu appears:




This menu displays regression coefficients, controls the scale, sets limits, and shows the process capability and omega conversion factors.

REG shows the regression coefficients for the currently selected regression equation. Unlike the regression coefficients in statistics mode (which are always linear regression coefficients), these coefficients change when you select a new regression type.

SCALE selects whether the data is graphed linearly or as percentage of the total. This function does not affect scatter diagrams, regression curves, or box charts.

LIMIT sets an upper and lower limit. Vertical bars are drawn on the screen at the limit points and at the mean value of x. The limit values are used to calculate process capability.

C.P. displays process capability values.[9]

[9] $Cp=\frac{\text{(upper limit-lower limit)}}{6\sigma}$

$Cpk=\frac{\text{(upper limit - }\bar{x})}{3\sigma}$ or $\frac{(\text{lower limit }-\bar{x})}{3\sigma}$ whichever is less.



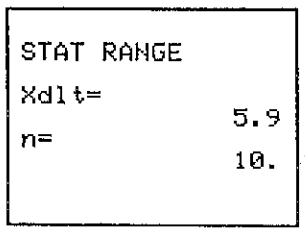


OMEGA displays the omega conversion values.[10]

## The [RANGE] key

As described in Chapter 4, [RANGE] lets you set the graph display range. If you specify a range, the number of points graphed depends upon the number of data cards. Since each point has a width expressed as a number of pixels (screen dots), it is important that the number of points in the selected range does not exceed the screen's width.

When you press [RANGE], a menu similar to the following appears:




Xdlt is the change in x each time you press [▶]. This number directly affects the number of points plotted (n).

n is the number of points plotted.[11] This number is limited by screen width. For histograms, broken-line graphs, and cumulative frequency graphs this number cannot exceed 31. For box charts this number cannot exceed 11. Do not confuse this number with the number of observations. They are not the same.

[10] $p=\frac{1}{1+10^{-\left(\frac{y}{10}\right)}}$

$y=10\log\left(\frac{1}{p-1}\right)$

[11] $n=\frac{\left(\text{Xmax-Xmin}+\frac{\text{(Xmax-Xmin)}}{95}\right)}{\text{Xdlt}}$

95 is the number of pixels across the screen used for graphing.

If you enter Xdlt, n is recalculated. If you enter n, Xdlt is recalculated. Values that are too large produce errors.



# CHAPTER 8: Solving Equations SOLVER

Note: Solver functions are available only on the EL-9300.

This chapter describes how to use the EL-9300's solver mode to solve equations. First, enter an equation. Second, assign values to the known variables. And lastly, use one of three methods to calculate the unknown variable. You can also create a library of frequently used equations.

The solver function can solve for any variable anywhere in an equation. It can even solve for a variable that appears several times in an equation.

Enter solver mode by pressing [2ndF] [SOLVER].

## Entering equations

The first step in solving equations is to enter the equation into your calculator. You do not need to transform your equation for the unknown variable. Once the equation is entered, you can select any variable as the unknown.

The rules of arithmetic precedence, as discussed in Chapter 2, apply to the equations you enter. You can use any of the mathematical functions assigned to calculator keys and the functions found in the [MATH] menu; these include absolute value and hyperbolic trigonometric functions. Multiplication symbols are assumed (for example, 3z=2x+y is a valid equation), but you may need to enter them in some cases, such as between two lower case variables, to differentiate them from a two-letter variable name (for example, z=2xy is different than z=2x*y).

In solver mode, the case of your variables makes a difference:

- Single uppercase letters (A to Z and θ) are global variables. Global variables correspond to the memories of the calculator. (For example, C in an equation means memory C of the calculator.) Global variables allow your equations to use values stored in memories, or to pass variables from one equation to another. Global variables also allow you to store results from this mode to use in any mode. To use uppercase letters, press the [ALPHA] and [2ndF] keys before pressing the letter.
- Lowercase letters, lowercase numbers ([2ndF] *number*), and lowercase words are local variables. (For example, you may choose to use c in an equation as a local variable.) Local variables exist only while the equation exists. When the equation is cleared, the local variables are cleared.
- Uppercase and lowercase letters cannot be mixed to form one variable. The single uppercase letters will always be taken as a single variable.

Your equation must include an equal sign ([ALPHA] [ENTER]).

**Example:** Enter the equation to convert temperature between Fahrenheit (degf) and Centigrade (degc):

$$degf=\frac{9}{5}degc+32.$$

Press: [2ndF] [SOLVER]
Press: [EQTN] [CL] Clear any old equations.
Press: [2ndF] [A·LOCK] degf= [ALPHA] 9 [%] 5 [▶] [2ndF] [A·LOCK] degc [ALPHA] [+] 32 [ENTER]

If your equation is entered incorrectly, you may get the message `ERROR 1: [Syntax]`. Pressing [◀] or [▶] shows you the problem area of the equation.

# Assigning values to the variables

After entering your equation, you need to assign values to the known variables. Global variables may already have values assigned to them, but you can change them for your calculation. As you assign variable values, the value is displayed below and to the right of the variable name.





**Example:** Convert 39.6 °C to Fahrenheit.
Press: [▼] 39.6 [ENTER]
[ENTER] Select degf as the unknown.

```
degf=
                    ?
degc=
                 39.6
 Press [ENTER]
 to solve
```

The unknown variable has a question mark for its value.
Press: [ENTER] Solve the equation.
Result: 103.28

# Solving equations

After you've moved the cursor to the variable that you want to solve for, press [ENTER] to solve the equation (it does not matter if the variable already has a value). `BUSY` is displayed at the top of the screen when drawing graphs and `COMPUTING` is displayed during the computation. The following screen shows the computational method used to solve the equation, and the result:

```
Equation solver
degf=
                 103.28

Press [ENTER]
```

After the equation is solved, you can press [ENTER] to display the variable list. You can change the values of the variables or select a different unknown and solve the equation again.

If the calculator cannot find a solution, you will get the message `No solution in range` or `Calculate`.

Press the [EQTN] key to display the equation if you need to edit it.

The next two examples demonstrate the convenience of entering an equation once, then using it to solve for different variables.

**Example:** Use the ideal gas law, pv=nRt,[12] to calculate the universal gas constant (R) in SI units.

Press: EQTN CL — Clear any loaded equation.

Press: ALPHA p x 2ndF A·LOCK v = n 2ndF R t ALPHA ENTER — Enter the ideal gas law.

Press: 1.013 ENTER .0224 ENTER 1 ENTER ▼ 273 ENTER
You've entered standard conditions for p, v, n, and t.

Press: ▼ ▼ ▼ ENTER ENTER — Select R as the unknown.

Result: 8.311794872 J/mole-K (0.000083117)

**Example:** Calculate the volume of 12 moles of oxygen at standard conditions.

Press: ENTER ▲ 12 ENTER ▲ ▲ ENTER ENTER

Result: v=0.2688 $m^3$

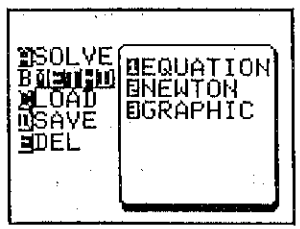
[12] p= pressure (standard conditions: 1.013 $N/m^2$)
v=volume (standard conditions: .0224 $m^3$)
n=number of moles (standard conditions: 1)
R=universal gas constant
t=temperature (standard conditions: 273 K)





# Solver methods

Solver mode has three methods for solving equations: Equation, Newton, and Graphic. To change the solver method, press MENU B, then select the desired method.




## Equation method

The equation method is used when an exact solution can be found by simple algebraic methods (rearranging the variables to solve for the unknown). This is the default method. The previous temperature conversion and gas law examples were solved by this method

## Newton method

For more complicated equations, the Newton method will be used. This is a numerical analysis method that uses an iterative technique to approximate the root. You must enter an initial estimate of the solution (START) and a step size (STEP) that it uses to determine successive estimates. It continues with this technique until the right and left sides of the equation are within a defined tolerance.

**Example:** Calculate the interest rate for a $5000 investment that will pay $20000 in 5 years. Use the equation $s=p(1+i)^n$.

Press: EQTN CL — Clear the loaded equation.

Press: 2ndF A·LOCK s = p ALPHA ( 1 + ALPHA i ) a^b ALPHA n ENTER — Enter the equation.

Press: 20000 ENTER 5000 ENTER ▼ 5 ENTER ▼ ▼ ENTER — Enter the known variables.

The calculator automatically switches to the Newton method, because the equation cannot be solved using the equation method.

Press: [ENTER] 0 [ENTER] 0.001 [ENTER]
Set the Newton solver parameters.

```
Newton solver
START=
                0.
STEP=
            0.001
Press [ENTER]
```

Press: [ENTER]
Result: i=0.31950791 (A 32% return!)

```
i=
       0.31950791
RIGHT=
           20000.
LEFT=
           20000.
Press [ENTER]
```

The resulting display shows the solution and the value of the right and left sides of the equation. The RIGHT and LEFT values can be compared to determine the error in the solution. A large difference in these values may indicate an asymptote or discontinuity in the function; in this case, specify a starting point that moves the calculation away from the discontinuity or asymptote. The RIGHT and LEFT values may also differ if the solution is actually a local minimum or maximum. The closer these are, the more accurate the solution is likely to be. If the difference is great, the solution should not be considered accurate. If the error in the solution is large, set the START value slightly below the displayed solution and the STEP value slightly above. This may yield a more accurate answer.

If the parameters for the Newton solver are too restrictive, you get the error message ERROR 02 [Calculate]. For example, you will get this error if the starting value is too far from the solution or if the step size is too small.





## Graphic method

The Graphic solver plots the right and left sides of the equation. If you lack the information to estimate a good starting point for your function with the Newton solver, then you should start with the Graphic solver. A graph of the function can be helpful for approximating multiple roots or determining discontinuities, asymptotes, or local minima and maxima.

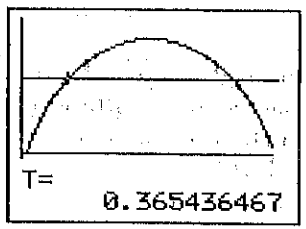
You must enter the range (BEGIN and END) where this method will look for a solution. If a root is found, a blinking cursor indicates the solution at the intersection of the two functions; the root is also displayed at the bottom of the screen. If you get the message No solution in range, you should enter another range to search for solutions. After you've found a solution, you can use the [ZOOM] function to view a portion of a graph in more detail. (For more information on this feature, refer to Chapter 4.)

**Example:** Determine how long it will take a ball tossed vertically in the air at 10m/sec to reach 3m. Use the equation for planar motion $0.5gt^2+vt+dstart=d$, where g is gravitational constant -9.8 $m/s^2$, v is initial velocity, d is distance, and t is time.

Press: [EQTN] [CL] Clear the loaded equation.
Press: [MENU] [B] [3] Use the Graphic solver.
Press: 0.5 [ALPHA] g [x] [ALPHA] [2ndF] T [$x^2$] [+] [ALPHA] v [x] [ALPHA] [2ndF] T [+] [2ndF] [A·LOCK] dstart = d [ALPHA] [ENTER] Enter the equation.
Press: [(-)] 9.8 [ENTER] [▼] 10 [ENTER] 0 [ENTER] 3 [ENTER] [▼] [ENTER] [ENTER] Enter the known variables, and solve for T.
Press: 0 [ENTER] 2 [ENTER] Set the range.

```
Graphic solver
Variable range
BEGIN=
                0.
END=
                2.
Press [ENTER]
```

Press: [ENTER]
Result: T=0.365436467




Note: A discontinuous function may be regarded as a continuous function to solve an equation

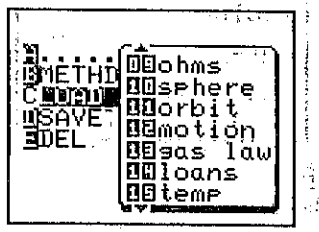
# Equations with multiple roots

The solver stops processing when it finds the first solution for the equation. If there are other roots, you can change the solver parameters to search in a different range. For the Newton solver, you can change the START parameter; for the Graphic solver, you can change the BEGIN and END parameters, or if more than one solution is displayed on the screen, you can jump to the other solutions.

**Example:** Find the second root of the above motion example.
Press: [2ndF] [JUMP]
Result: 0=1.675379859

# The solver menu

Besides selecting the solver method, [MENU] lets you load, save, and delete equation files. Press [MENU] [C] and a menu similar to the following appears:








## Loading equations

Before using an equation that you've saved, you must make it the active equation in the calculator. To load an equation, press [MENU], select the LOAD option (C), then highlight the desired equation and press [ENTER]. Press [ENTER] to confirm that you want to clear the old equation and load the new equation. If there are no equation files, the right side of the screen will be empty.

## Saving equations

You can save equations for future use, and set up an equation library of frequently used equations. To save an equation, press [MENU] [D] [ENTER], then enter a name for the equation (up to 14 characters) and press [ENTER].

**Example:** Save the planar motion equation as *motion*.
Press: [MENU] [D] [ENTER] Select the SAVE function.
Press: motion [ALPHA] [ENTER] Save *motion*.

## Deleting equations

To remove an equation that you've saved, press [MENU], select the DEL option (E), then select the desired equation. Press [ENTER] to confirm the deletion, or press [QUIT] to cancel. Equations listed below the deleted equation will automatically move on the list.

# The option menu

The option menu lets you copy, move, and print equation files. See Chapter 2 for more information on using [2ndF] [OPTION].

# CHAPTER 9: Getting Results

This chapter contains solved problems from a number of fields that demonstrate the power of your Sharp calculator.

## Math and physics

### Geosynchronous orbits

The orbit of a satellite about the earth is a geosynchronous orbit if the period of the orbit matches the period of the earth's rotation. At what distance from the center of the earth can geosynchronous orbit occur?

The period of an orbit is described by the equation:

$$T^2 = \frac{4\pi^2}{GM} r^3$$

Where:
- T = Period of orbit
- G = Gravitational constant ($6.672 \times 10^{-11}$ $Nm^2kg^{-2}$)
- M = Mass of the earth ($5.976 \times 10^{24}$ kg)
- r = Distance (radius) between the satellite and the center of the earth

The earth rotates once every 23 hours, 56 minutes, and 4.09 seconds. Convert this time to seconds:

| | | |
|---|---|---|
| Press: | [▦] [MENU] [A] [1] 23.560409 | |
| | [MATH] [D] [1] [X] 60 [$x^2$] [ENTER] | |
| Result: | 86164.09 | This is T. |
| Press: | [STO] T | Store this in T. |

Two of the numbers used in this equation only have three significant digits after the decimal point. Select scientific display format with three decimal places, and equation edit mode.

Press: [SET UP] [C] [3] [D] [3] [F] [1] [ENTER]

On the EL-9300, use the solver to solve the equation for r.

Press: [2ndF] [SOLVER] [CL] [ALPHA] [2ndF] T [$x^2$] [ALPHA] =
4 [2ndF] [π] [$x^2$] [%]
[ALPHA] g [X] [ALPHA] m [▶] [ALPHA] r [$a^b$] 3 [ENTER]

Select the graphic solver:

Press: [MENU] [B] [3]

~~Press:~~ [2ndF] [RCL] T [ENTER] 6.672 [Exp] [(-)] 11 [ENTER]
5.976 [Exp] 24 [ENTER]

Position the cursor on r and press [ENTER] [ENTER] to solve for r.

It's safe to assume that the orbit is above the surface of the earth (the earth's radius is approximately $6.378 \times 10^6$ meters), but less than 10 times that distance away. Set BEGIN to $6.378 \times 10^6$ and END to $6.378 \times 10^7$.

Press: 6.378 [Exp] 6 [ENTER]
6.378 [Exp] 7 [ENTER] [ENTER]

Result: $4.217\ E^{07}$ The radius in meters. About 42,170 kilometers from the center of the earth.

On the EL-9200, rearrange the equation to solve for $r^3$:

$$r^3 = \frac{GMT^2}{4\pi^2}$$

Press: [▦] 6.672 [Exp] [(-)] 11 [x] 5.976 [Exp] 24 [x] [2ndF] [RCL] T
[$x^2$] [÷] [(] 4 [x] [2ndF] [π] [$x^2$] [)] [=]

Result: $7.498\ E^{22}$ This is $r^3$.

Press: 3 [2ndF] [$\sqrt[a]{}$] [2ndF] [ANS] [ENTER]

Result: $4.217\ E^{07}$ The radius in meters.

Geosynchronous orbit occurs at a radius of 42,170 kilometers from the center of the earth.

## Twinkle, twinkle, little star

The **apparent magnitude** of a star tells how bright it appears. The apparent brightness of a star is determined by how far away the star is and the luminosity of the star.

Since stars are seen from different distances, their luminosities must be standardized in order to be compared. This is done using a quantity called





the **absolute magnitude**. The absolute magnitude of a star tells how bright that star would appear if viewed from a distance of ten parsecs (about 32.6 light years). If the absolute magnitude of two stars is known, the ratio of their luminosities is:

$$\log \frac{L_2}{L_1} = 0.4\,(M_1 - M_2)$$

Where:
- $M_1$ = the absolute magnitude of the first star
- $M_2$ = the absolute magnitude of the second star
- $L_1$ = the luminosity of the first star
- $L_2$ = the luminosity of the second star

What is the ratio of the sun's luminosity to that of a star having an absolute magnitude of 2.89?

Rearranging the above equation:

$$\frac{L_2}{L_1} = 10^{0.4(M_1 - M_2)}$$

In this case, $M_2 = 2.89$.

Press: [▦] [SET UP] [C] [1] [F] [1] [ENTER] [2ndF] [$10^x$]
0.4 [x] [(] 4.8 [-]
2.89 [)] [ENTER]

Result: 5.807644175 The star is nearly six times as luminous as the sun.

A second star has only 0.0003 the luminosity of the sun. What is its absolute magnitude?

Rearranging the first equation to solve for $M_2$:

$$M_2 = M_1 - \frac{\log \frac{L2}{L1}}{0.4}$$

In this case, $\frac{L_2}{L_1} = 0.0003$.

Press: 4.8 [-] [(] [log] 0.0003 [÷] 0.4 [)] [ENTER]

Result: 13.60719686

## Radioactive decay

Carbon-14 ($^{14}C$) is a naturally occurring radioactive isotope of carbon, used in the carbon dating process. Because carbon-14 decays at a steady rate, it is possible to determine the age of a once living specimen by measuring the remaining amount of $^{14}C$ it contains. The mass of $^{14}C$ contained in a sample changes according to this equation:

$$M = M_0 e^{-kt}$$

Where:
- $M$ = mass of $^{14}C$ at time t
- $M_0$ = original mass of $^{14}C$
- $k$ = constant of decay (for $^{14}C$, $k = 1.2118 \times 10^{-4}$ year$^{-1}$)
- $t$ = elapsed time in years

Solving for t:

$$t = \frac{-\ln\left(\frac{M}{M_0}\right)}{k}$$

Write a program that asks for the starting and ending mass of $^{14}C$, and tells you how old the specimen is.

Press:
[Prgm] [C] [ENTER] [1]
d e c a y [ALPHA] [ENTER]
[2ndF] [COMMAND] [A] [1] [2ndF] [COMMAND] [A] [2] [2ndF] [A·LOCK] starting [SPACE] mass [ALPHA] [ENTER]
[2ndF] [A·LOCK] start [ALPHA] [ENTER]
[2ndF] [COMMAND] [A] [1] [2ndF] [COMMAND] [A] [2] [2ndF] [A·LOCK] ending [SPACE] mass [ALPHA] [ENTER]
[2ndF] [A·LOCK] end [ALPHA] [ENTER]
[2ndF] [A·LOCK] time = [ALPHA] [(-)] [(] [ln] [(] [2ndF] [A·LOCK] end [ALPHA] [÷] [2ndF] [A·LOCK] start [ALPHA] [)] [)] [÷] 1.2118 [Exp] [(-)] 4 [ENTER]
[2ndF] [COMMAND] [A] [1] [2ndF] [A·LOCK] time [ALPHA] [ENTER]
[2ndF] [COMMAND] [A] [1] [2ndF] [COMMAND] [A] [2] [2ndF] [A·LOCK] years [ALPHA] [ENTER]





The finished program should look like this:

```
Print "starting mass
start
Print "ending mass
end
time=-(ln(end/start))/1.2118E-4
Print time
Print "years
```

To run the program, press [MENU] [A], use the cursor keys to select the program, and press [ENTER].

The half-life of an element is the time required for half of the mass to decay away. What is the half-life of ($^{14}C$)?

**Example:** Use the program to calculate the half-life of $^{14}C$. Run the program.

start=?
Press: 100 [ENTER]
end=?
Press: 50 [ENTER]
Result: 5719.980034 years.

## Exponential growth

Exponential mathematics can often give unexpected results. The following example illustrates this.

The town you live on relies on a certain resource for its existence. For years the town uses only one thousandth of the available resource every year, exactly the rate at which it is renewed. Suddenly, the town begins growing at a rate such that each year the town uses exactly twice as much of the resource as it did the year before.

How long will it take to use up the resource, and how long before then will your town notice the problem?

What you are concerned with is the amount of resource remaining. Before the change in the amount used, you could write the amount remaining each year as follows. (For simplicity, set the starting amount of the resource equal to 1.)

$$\text{amount left} = 1 + \frac{1}{1000} - \frac{1}{1000} = 1$$

During the first year of growth, the amount used is twice that of the previous year, or two-thousandths of the total. On the second year the amount used is four-thousandths, and so forth. The amount left at year X can be represented as:

$$\text{amount left} = 1 + \frac{1}{1000} - \frac{2^X}{1000}$$

Now use the graph trace feature to determine the amount of the resource remaining over the next few years.

Press: SET UP E 1 ↵ (F 1)
Enter the above equation.
Press: 1 + 1 % 1000 ▶ - 2 $a^b$ X/θ/T ▶ % 1000 RANGE MENU C 3 ▼ 10 ENTER ↵
Determine the x-intercept,
Press: 2ndF JUMP 4
Result: x=9.967226, y=0

The resource would have been used up some time between the ninth and tenth years.

Looking only at the first 5 years, the town's people could be greatly misled about the amount of the resource left, and how long it would last. Even at the start of the ninth year almost half of the resource would still exist.

# Engineering

## Angle vs. percent grade

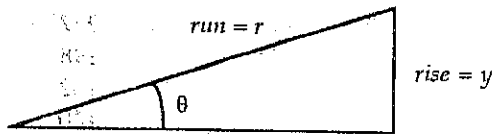
One street in your neighborhood was built on a 6% grade. Another has a slope of 3° . Which street is steeper?

The problem can be solved by converting either measurement into the units of the other and comparing the results. In this case, convert the percent grade into degrees of angle.

Grade equals *rise over run*. Percent grade is grade times 100. Notice that rise over run is the same as the *sin* of the angle.








$$\sin(\theta) = \frac{y}{r} = \frac{\text{rise}}{\text{run}}$$

The equation is:

$$\sin(\theta) = 6\%$$

or:

$$\theta = \sin^{-1}(0.06)$$

Make sure DEG is selected. To convert a 6% grade to degrees:
Press: ▦ SET UP B 1 ENTER 2ndF $\sin^{-1}$ 0.06 ENTER
Result: 3.439812768 In degrees
The 6% grade can be rounded to a 3.44° angle. It is the steeper street.

# Statistics

## School days

Mr. Ringle teaches math at the local high school. He is giving his class a long and difficult test to see who qualifies for an advanced math program at the local university. Since the test is so difficult, he has decided to score using a standard Bell curve as follows: Anyone whose score is more than a standard deviation above the class mean score automatically qualifies for the advanced math program. Anyone who gets a score lower than a standard deviation below the class mean is eliminated. Those who score within a standard deviation of the mean will have to take another test to qualify.

The class scores are as follows:

| | | | | |
|---|---|---|---|---|
| 499 | 427 | 375 | 300 | 227 |
| 487 | 425 | 371 | 291 | 198 |
| 474 | 420 | 360 | 272 | 162 |
| 468 | 413 | 352 | 268 | 140 |
| 462 | 401 | 349 | 264 | 115 |
| 455 | 396 | 327 | 256 | 97 |
| 453 | 390 | 322 | 255 | 65 |
| 433 | 384 | 308 | 243 | 34 |

How many students qualify for the advanced program? How many are eliminated?

Start by entering the data in statistics mode.

Press: [≡] 1 If the statistics memory isn't empty clear it ([MENU] [D] [2] [ENTER]) and select single variable data (X).

Press: 499 [ENTER] 487 [ENTER] 474 [ENTER] 468
(continue to enter all data items)

Now graph a histogram of the data and set limits at $\bar{x}$ plus and minus one population standard deviation ($\sigma x$) to see how many student qualify and how many are dropped.

Press: [2ndF] [graph] [MENU] [C] [1] [MATH] [E] [1]
[÷] [MATH] [3] [ENTER]
[MATH] [1] [+] [MATH] [3] [ENTER]
[EQTN] [A] [2ndF] [AUTO]

Result: A histogram is drawn.

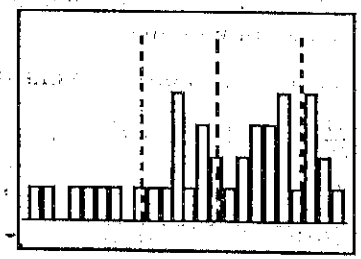




Change the range to get a clearer view of the data. Set `Xdlt` to 20, `Xmin` to 30, and `Xmax` to 520.

Press: [RANGE] 20 [ENTER] [▶] [▲] 30 [ENTER]
520 [ENTER] [EQTN] [ENTER]

Result:



Using [▶] and [◀] to look at the number of scores above and below the set limits shows that seven students qualify, and seven others are eliminated.

# Fun and games

## Put on the bite

Mary visits the dentist, spending exactly 25 minutes in his office. The bill for her visit comes to $93.50. What is the dentist's equivalent wage per hour?

Press: [calc] [SET UP] [C] [1] [ENTER] 93.50 [÷] 0.25
[MATH] [D] [1] [ENTER]

Result: 224.4 $224.40 an hour.

## The lottery

The state you live in has two different lotteries. In the first, you must pick six digits between 1 and 50, in any order. In the second, you have to pick five digits between 1 and 35, but you must pick them in the correct order. Which lottery gives you a better chance of winning?

In the first lottery, your chances of winning with one ticket are one in ${}_{50}C_6$:

Press: 50 [MATH] [A] [6] 6 [ENTER]
Result: 15890700.

Your chances of winning the second lottery with one ticket are one in ${}_{35}P_5$:

Press: 35 [MATH] [A] [7] 5 [ENTER]
Result: 38955840.

Your chances are better in the first lottery.

## Boxing

Cliff has built a small wooden chest that measures $6\frac{1}{2} \times 8\frac{1}{2} \times 12$. A customer comes into his shop one day, and asks if she could get a similar box, only $\frac{1}{4}$ larger. What size box would Cliff have to build?

To get the size of the new box, multiply the dimensions of the existing box by $\frac{5}{4}$. Before you start the calculation change the answer mode to mixed.

Press: [SET UP] [G] [2] [ENTER]
5 [%] 4 [STO] A
[ALPHA] A [×] [(] 6 [+] 1 [%] 2 [ENTER]
Result: $8\frac{1}{8}$
Press: [ALPHA] A [×] [(] 8 [+] 1 [%] 2 [ENTER]
Result: $10\frac{5}{8}$
Press: [ALPHA] A [×] 12 [ENTER]
Result: 15.

The new box's dimensions would be $8\frac{1}{8} \times 10\frac{5}{8} \times 15$.



# APPENDIX A: Replacing the Batteries

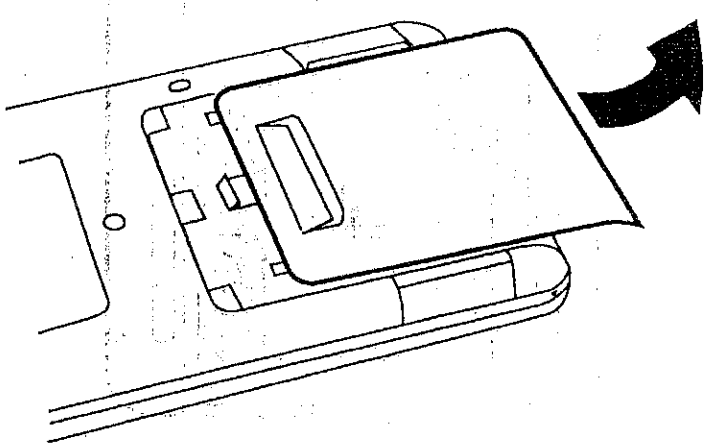
The calculator uses two types of batteries; 4 AAA batteries power the calculator and screen, and in the EL-9300, a lithium battery provides backup power. With normal use, the AAA batteries last about 6 months (or 140 hours), and the lithium backup battery lasts 5 years.

Note: To prevent loss of stored data, replace only one type of battery at a time.

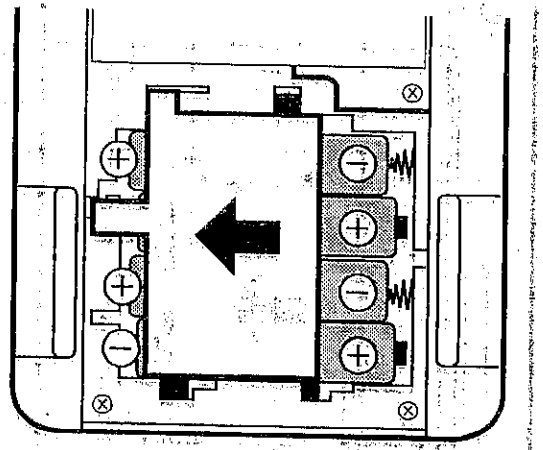
When BATT appears in the display, replace the AAA batteries as follows:

Note: If you continue using the calculator after BATT has been displayed, power may not turn on after [ON] is pressed. When BACKUP BATTERY LOW warning message appears on the EL-9300 after [ON] is pressed, replace the backup battery first.

1. Turn the calculator off by pressing [2ndF] [OFF].
2. Turn over the calculator and locate the battery compartment cover.
3. Pull the cover out a short distance until it stops, then lift the cover off the calculator, as shown in this illustration:



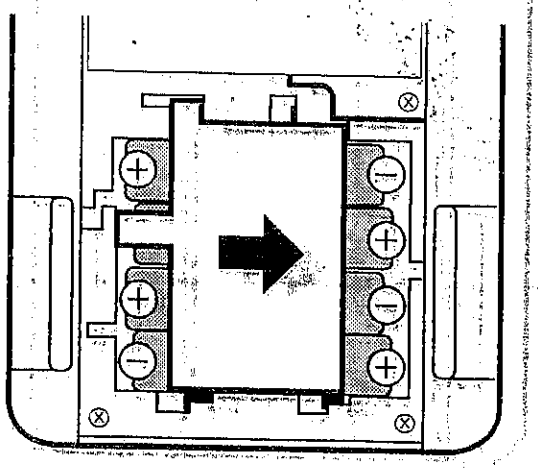
4. Carefully slide the AAA-battery plate to the left until it stops:



5. Lift off the plate and replace the batteries. Be sure to orient the batteries as shown in the above illustration.

   Caution for EL-9200: Once the 4 AAA batteries are out, they should be replaced within 1 minute to prevent loss of stored data.

6. Replace the plate and slide it to the right:







7. Replace the battery compartment cover.

8. Press the reset button. The following message appears.

```
PRESS [CL] TO
CLEAR ALL DATA.

PRESS [ON] KEY
TO CANCEL
```

   If you don't see the message, try again (repeat steps 1 to 7).

9. Press [ON].

   Caution: Do not press [CL]. This will clear all data.

10. Adjust the display contrast.

    (Press [2ndF] [OPTION] and press [+] or [-] until the contrast is set correctly.)

Note: For the EL-9200, if battery replacement took more than 1 minute in step 5, the following message may appear when [ON] is pressed. If this occurs, press [CL] to initialize the calculator and clear all data.

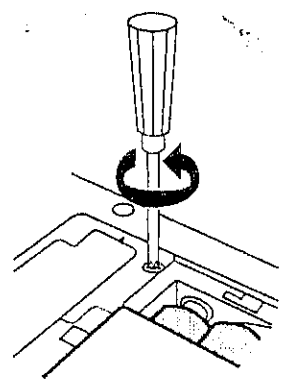
```
Calculator is
not initialized,
or memory has
been impaired.

Press [CL] to
INITIALIZE and
CLEAR ALL DATA.
```

On the EL-9300, when BACKUP BATTERY LOW warning message appears, after power is turned on by [ON] being pressed replace the battery as follows:

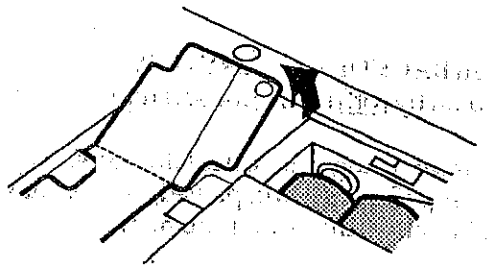
Note: If you continue using the calculator after the backup battery warning message has been displayed, power may not turn on and you risk losing all of the stored memory.

1. Open the battery compartment cover following steps 1, 2 and 3 of the previous procedure.

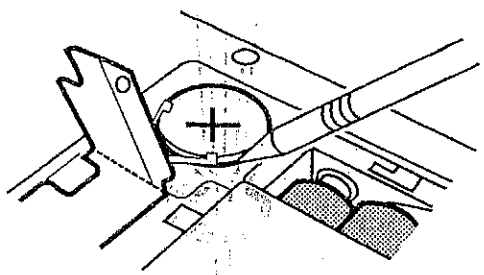
2. Using a small Phillips screwdriver, unscrew and remove the screw holding the backup battery cover:



3. Carefully tilt the cover up:



4. Using a pen or the screwdriver as a lever, lift the battery out of its compartment:



5. Replace the battery with an identical 3V lithium battery (CR2032 or equivalent). Make sure that the plus (+) sign faces up.
6. Replace the battery cover and the screw.
7. Replace the battery compartment cover.



# APPENDIX B: Error Messages

The following is a table of common error messages and suggestions for correcting the cause of the error:

| Error Number | Error Message | Solution |
|---|---|---|
| 01 | Syntax | Use this manual to verify that you are using the proper syntax for the function you are trying to use. |
| 02 | Calculate | Check that you haven't attempted to divide by zero or make some other calculation error. |
| 03 | Nesting | Make sure your calculations have less than 14 numbers and 32 functions within sets of nested parentheses. |
| 05 | Dimension | Check that the dimensions of all matrices being added, subtracted, and multiplied are compatible with each other. If you are trying to set the dimension of a matrix, make sure that there is enough memory available. |
| 07 | No argument | Check that the faulty function has an argument. |
| 08 | Not pair ∫~dx | Check that every ∫ is paired with a dx. |
| 09 | Not pair [~] | Check that every [ is paired with a ]. |
| 10 | Line over | Equation edit mode only: your equation has run off the top or the bottom of the screen. |
| 11 | Cannot delete | You are trying to delete a function that cannot be deleted. |

# APPENDIX C:
# Command Index

The following table lists all of the commands in alphabetical order.

In the syntax column <arg> is a number or a function that results in a number; for example, 4, 5+3, and sin 35(cos 12) are valid arguments.

The abbreviation <str> means a string of characters (a word or a letter).

| Command | Description and keystrokes | Syntax | Page |
|---|---|---|---|
| ∫ | [MATH] [C] [2]<br>Integrate function.<br>*See also* dx.<br>Available in real mode only. | ∫*arg1*, *arg2*, *arg3*, *arg4* dx<br>*arg1*, *arg2*, *arg3* and *arg4* are expressions.<br>*arg1* is a function.<br>*arg2* is the initial value.<br>*arg3* is the final value.<br>*arg4* (optional) is the number of subintervals. The calculator uses 100 if no subinterval is specified. | 49 |
| $\bar{x}$ | [MATH] [E] [1]<br>Mean value of x data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |
| $\bar{y}$ | [MATH] [F] [1]<br>Mean value of y data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| $\sigma x$ | [MATH] [E] [3]<br>Population standard deviation of x data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |
| $\sigma y$ | [MATH] [F] [3]<br>Population standard deviation of y data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |

| | | | |
|---|---|---|---|
| π | [2ndF] [π]<br>Displays π. | No arguments. | 41 |
| ∠ | [MATH] [E] [2]<br>[2ndF] [∠]<br>Polar coordinate separator.<br>Available only in complex mode. | No arguments. | 74 |
| = | [2ndF] [COMMAND] [C] [1]<br>[ALPHA] [=]<br>Equal to. Available only while editing a program. | If *arg1* = *arg2* Goto *str*<br>*arg1* and *arg2* are expressions.<br>*str* is a label. | 101 |
| < | [2ndF] [COMMAND] [C] [2]<br>Less than.<br>Available only while editing a program. | If *arg1* < *arg2* Goto *str*<br>*arg1* and *arg2* are expressions.<br>*str* is a label. | 101 |
| <= | [2ndF] [COMMAND] [C] [3]<br>Less than or equal to.<br>Available only while editing a program. | If *arg1* <= *arg2* Goto *str*<br>*arg1* and *arg2* are expressions.<br>*str* is a label. | 101 |
| >= | [2ndF] [COMMAND] [C] [4]<br>Greater than or equal to.<br>Available only while editing a program. | If *arg1* >= *arg2* Goto *str*<br>*arg1* and *arg2* are expressions.<br>*str* is a label. | 101 |
| > | [2ndF] [COMMAND] [C] [5]<br>Greater than.<br>Available only while editing a program. | If *arg1* > *arg2* Goto *str*<br>*arg1* and *arg2* are expressions.<br>*str* is a label. | 101 |
| ≠ | [2ndF] [COMMAND] [C] [6]<br>Not equal to.<br>Available only while editing a program. | If *arg1* ≠ *arg2* Goto *str*<br>*arg1* and *arg2* are expressions.<br>*str* is a label. | 101 |
| " | [2ndF] [COMMAND] [A] [2]<br>Denotes the beginning of a character string.<br>Available only while editing a program. | Print "*str*<br>*str* is a string of characters or numbers. | 102 |





| | | | |
|---|---|---|---|
| [ | [2ndF] [COMMAND] [F] [7] (in stat program mode)<br>[MATH] [E] [3] (in matrix mode)<br>Open bracket.<br>Used to reference matrix elements and with the dim function. | *St*[*arg1*,*arg2*]<br>St is a stat program command.<br>*arg1* can be 1, 2 or 3(represents x,y or w,w).<br>*arg2* is a card number.<br>*alpha* [*arg1*, *arg2*]<br>*alpha* is a letter key representing the matrix.<br>*arg1* is an expression for the row.<br>*arg2* is an expression for the column. | 66 |
| ] | [2ndF] [COMMAND] [F] [8] (in stat program mode)<br>[MATH] [E] [4] (in matrix mode)<br>Close bracket.<br>Used to reference matrix elements and with the dim function. | *St*[*arg1*,*arg2*]<br>St is a stat program command.<br>*arg1* can be 1, 2 or 3(represents x,y or w,w).<br>*arg2* is a card number.<br>*alpha* [*arg1*, *arg2*]<br>*alpha* is a letter key representing the matrix.<br>*arg1* is an expression for the row.<br>*arg2* is an expression for the column. | 66 |
| [(-)] | [(-)]<br>Change sign. | [(-)] *arg*<br>*arg* is an expression. | 4 |
| [(] | [(]<br>Left parenthesis. | (*arg*)<br>*arg* is an expression. | 20 |
| [)] | [)]<br>Right parenthesis. | (*arg*)<br>*arg* is an expression. | 20 |
| [+] | [+]<br>Add. | *arg1* + *arg2*<br>*arg1* and *arg2* are expressions. | 5 |
| [-] | [-]<br>Subtract. | *arg1* - *arg2*<br>*arg1* and *arg2* are expressions. | 5 |
| [X] | [X]<br>Multiply. | *arg1* x *arg2*<br>*arg1* and *arg2* are expressions. | 5 |
| [÷] | [÷]<br>Divide. | *arg1* ÷ *arg2*<br>*arg1* and *arg2* are expressions. | 5 |
| [$10^x$] | [2ndF] [$10^x$]<br>Exponential. | $10^{arg}$<br>*arg* is an expression. | 44 |

| | | | |
|---|---|---|---|
| 2ndF | 2ndF<br>Second function.<br>Activates the yellow function marked above the next key you press. | No arguments. | 10 |
| A·LOCK | 2ndF A·LOCK<br>Alpha lock.<br>Enters blue alpha symbols marked above the keys until you press ALPHA. | No arguments. | 10 |
| a b/c | a b/c<br>Fraction. | *arg1* a b/c *arg2*<br>*arg1* and *arg2* are expressions | 40 |
| $a^b$ | $a^b$<br>Power. | *arg1* $a^b$ *arg2*<br>*arg1* and *arg2* are expressions | 44 |
| ALPHA | ALPHA<br>Enters a blue alpha symbol marked above each key you press. | No arguments. | 10 |
| AUTO | 2ndF AUTO<br>Auto-scale.<br>Available only in graph and stat graph mode. | No arguments. | 86 |
| $\sqrt[a]{\ }$ | 2ndF $\sqrt[a]{\ }$<br>a th root. | *arg1* $\sqrt[a]{\ }$ *arg2*<br>*arg1* and *arg2* are expressions | 44 |
| BS | BS<br>Deletes character to left of cursor. | No arguments. | 5 |
| CA | 2ndF CA<br>Clears current calculation. In program mode, deletes entire program. In statistics mode, deletes entire card. | No arguments. | 94 |
| CL | CL<br>Clears the current calculation. | No arguments. | 8 |
| cos | cos<br>Cosine. | cos *arg*<br>*arg* is an expression. | 42 |
| $\cos^{-1}$ | 2ndF $\cos^{-1}$<br>Inverse cosine. | $\cos^{-1}$ *arg*<br>*arg* is an expression. | 42 |
| DEL | DEL<br>Deletes character at the cursor position. | No arguments. | 5 |
| ENTER | ENTER<br>Evaluates expression. | *arg* ENTER<br>*arg* is an expression. | 4 |





| | | | |
|---|---|---|---|
| EQTN | EQTN<br>Displays current equation (in graph mode) or displays statistics graph function (in statistics graph mode). | No arguments. | 79 |
| $e^x$ | 2ndF $e^x$<br>Exponential base *e*. | $e^x$ *arg*<br>*arg* is an expression. | 44 |
| INS | 2ndF INS<br>Inserts keystrokes at cursor location. | No arguments. | 93 |
| JUMP | 2ndF JUMP<br>Displays the jump menu. | No arguments. | 85 |
| i | 2ndF i<br>Inserts i (the imaginary number).<br>Available only in complex mode. | No arguments. | 74 |
| ln | ln<br>Natural log. | ln *arg*<br>*arg* is an expression. | 44 |
| log | log<br>Log in base 10. | log *arg*<br>*arg* is an expression. | 44 |
| MAT | MAT<br>Recalls matrix.<br>You don't need to press ALPHA when selecting the matrix.<br>Available only in matrix mode. | mat *alpha*<br>*alpha* is a letter key. | 63 |
| MATH | MATH<br>Displays the math functions menu.<br>Functions vary depending on mode. | No arguments. | 11 |
| MENU | MENU<br>Displays the menu for the current operation mode.<br>Menu varies depending on mode. | No arguments. | 12 |
| OFF | 2ndF OFF<br>Turns the calculator off. | No arguments. | 2 |
| ON | ON<br>Turns the calculator on. | No arguments. | 2 |
| OPTION | 2ndF OPTION<br>Displays the option menu. | No arguments. | 28 |

| | | | |
|---|---|---|---|
| PLOT | 2ndF PLOT<br>Displays the plot menu.<br>Available only in graph mode. | No arguments. | 86 |
| QUIT | QUIT<br>Leaves the current menu, matrix, or program. | No arguments. | 81 |
| RANGE | RANGE<br>Adjusts graphing range.<br>Displays the range entry screen.<br>Available only in graph and statistics graph modes. | No arguments. | 76 |
| RCL | 2ndF RCL<br>Recalls the value from a variable.<br>You don't need to press ALPHA when selecting the variable name. | RCL *alpha*<br>*alpha* is a letter key. | 9 |
| SET UP | SET UP<br>Adjusts the calculator parameters.<br>Displays the setup menu. | No arguments. | 12 |
| sin | sin<br>Sine. | sin *arg*<br>*arg* is an expression. | 42 |
| $\sin^{-1}$ | 2ndF $\sin^{-1}$<br>Inverse sine. | $\sin^{-1}$ *arg*<br>*arg* is an expression. | 42 |
| STO | STO<br>Stores a value in a variable.<br>You don't need to press ALPHA when selecting the variable name. | *arg* STO *alpha*<br>*arg* is an expression.<br>*alpha* is a letter key. | 37 |
| tan | tan<br>Tangent. | tan *arg*<br>*arg* is an expression. | 42 |
| $\tan^{-1}$ | 2ndF $\tan^{-1}$<br>Inverse tangent. | $\tan^{-1}$ *arg*<br>*arg* is an expression. | 42 |
| X/θ/T | X/θ/T<br>Enter X, θ, or T, depending on the coordinate mode.<br>Not available in matrix mode. | No arguments. | 9 |
| $\sqrt{\ }$ | $\sqrt{\ }$<br>Square root. | $\sqrt{\ }$ *arg*<br>*arg* is an expression. | 44 |
| $x^2$ | $x^2$<br>Square. | *arg* $x^2$<br>*arg* is an expression. | 43 |





| | | | |
|---|---|---|---|
| $x^{-1}$ | 2ndF $x^{-1}$<br>Inverse. | *arg* $x^{-1}$<br>*arg* is an expression. | 44 |
| ZOOM | ZOOM<br>Displays the zoom menu.<br>Available only in the graphing modes. | Select item. | 84 |
| SOLVER | 2ndF SOLVER<br>Enters solver mode.(EL-9300 only) | No arguments. | 139 |
| | <br>Enters statistics mode. | No arguments. | 113 |
| | <br>Enters program mode. | No arguments. | 91 |
| | <br>Enters graph mode. | No arguments. | 75 |
| | 2ndF <br>Enters statistics graph mode. | No arguments. | 129 |
| | <br>Enters calculator mode. | No arguments. | 3 |
| →bin | MATH D 4<br>Changes to binary (base 2).<br>Available only in nbase mode. | *arg* →bin<br>*arg* is an expression. | 55 |
| →dec | MATH D 2<br>Changes to decimal (base 10).<br>Available only in nbase mode. | *arg* →dec<br>*arg* is an expression. | 55 |
| →deg | MATH D 1<br>Changes from sexagesimal to degrees.<br>Available only in real mode. | dd.mmss →deg<br>dd.mmss is an expression. | 50 |
| →dms | MATH D 2<br>Changes to degrees, minutes, and seconds (sexagesimal).<br>Available only in real mode. | *arg* →dd.mmss<br>*arg* is an expression. | 51 |
| →hex | MATH D 1<br>Changes to hexadecimal (base 16).<br>Available only in nbase mode. | *arg* →hex<br>*arg* is an expression. | 55 |
| →oct | MATH D 3<br>Changes to octal (base 8).<br>Available only in nbase mode. | *arg* →oct<br>*arg* is an expression. | 55 |

| | | | |
|---|---|---|---|
| →rθ | MATH D 3<br>Changes to polar coordinates.<br>Calculator displays r, θ is stored in the θ memory. | *arg1* , *arg2* →rθ<br>*arg1* and *arg2* are expressions. | 51 |
| →xy | MATH D 4<br>Changes to rectangular coordinates.<br>Calculator displays x ; y is stored in the Y memory.<br>Available only in real mode. | *arg1* , *arg2* →xy<br>*arg1* and *arg2* are expressions. | 51 |
| a | MATH G 1<br>First coefficient of linear regression (y-intercept).<br>Available only in real mode. | No arguments. | 53 |
| a+bX | 2ndF [graph] F 1<br>Selects a linear regression graph.<br>Available only statistics graph mode. | No arguments. | 133 |
| a*e^bX | 2ndF [graph] F 2<br>Selects an exponential regression graph.<br>Available only statistics graph mode. | No arguments. | 133 |
| a+b*lnX | 2ndF [graph] F 3<br>Selects a logarithmic regression graph.<br>Available only statistics graph mode. | No arguments. | 133 |
| a+b*logX | 2ndF [graph] F 4<br>Selects a logarithmic base 10 regression graph.<br>Available only statistics graph mode. | No arguments. | 133 |
| a*X^b | 2ndF [graph] F 5<br>Selects a power regression graph.<br>Available only statistics graph mode. | No arguments. | 133 |
| a+b*X^-1 | 2ndF [graph] F ▶ 6<br>Selects an inverse regression graph.<br>Available only statistics graph mode. | No arguments. | 133 |





| | | | |
|---|---|---|---|
| abs | MATH A 1<br>Absolute value. | abs *arg*<br>*arg* is an expression. | 46 |
| ALL DATA | MENU D 2<br>Deletes all statistics data.<br>2ndF OPTION E 4 (2ndF OPTION E 3 for EL-9200)<br>Deletes all statistics and matrix date. | No arguments. | 31 |
| ALL GRPH | 2ndF OPTION E 1<br>Deletes all graph files. | No arguments. | 31 |
| ALL MEM. | 2ndF OPTION E 5 (2ndF OPTION E 4 for EL-9200)<br>Deletes all files and all data. | No arguments. | 31 |
| ALL PROG | 2ndF OPTION E 2<br>Deletes all program files. | No arguments. | 31 |
| ALL SOLV | 2ndF OPTION E 3<br>(EL-9300 only)<br>Deletes all solver files. | No arguments. | 31 |
| and | MATH E 1<br>Logical AND operation.<br>Available only in nbase mode. | *arg1* and *arg2*<br>*arg1* and *arg2* are expressions. | 56 |
| ANS | 2ndF ANS<br>Most recent answer. | No arguments. | 38 |
| ANY CARD | MENU B 3<br>Goes to specified card.<br>Available only in statistics mode. | Enter card number. | 123 |
| arg | MATH E 5<br>Returns the argument.<br>Available only in complex mode. | arg *arg*<br>*arg* is a complex expression. | 74 |
| Auto | 2ndF COMMAND D 2<br>Selects a Y range and performs the specified graph command.<br>Available only in real and stat programs. | auto *graph command*<br>*graph command* is Graph, DotGraph, Fill, or any statistics graph command. | 96 |
| AUTO | ZOOM 5<br>Magnifies the graph.<br>Available only in graph mode. | No arguments. | 85 |
| b | MATH G 2<br>Second coefficient of linear regression (slope).<br>Available only in real mode. | No arguments. | 53 |

| | | | |
|---|---|---|---|
| B.C. | 2ndF [graph] G<br>Draws a box chart from current statistical data.<br>Available only in statistics graph mode. | No arguments. | 134 |
| B.L. | 2ndF [graph] B<br>Draws a broken line chart from current statistical data.<br>Available only in statistics graph mode. | No arguments. | 130 |
| B.VER | 2ndF OPTION G ENTER F<br>Verifies that the data on a cassette tape matches calculator data after a back-up. (EL-9300 only.) | No arguments. | 35 |
| BKUP | 2ndF OPTION G ENTER D<br>Backs up data to a cassette recorder or another calculator. (EL-9300 only.) | No arguments. | 34 |
| BOX | ZOOM 1<br>Draws a box that becomes the new view window.<br>Available only in graph mode. | No arguments. | 84 |
| BRNCH | 2ndF COMMAND B<br>Displays program branching commands.<br>Available in program mode only. | Select item. | 107 |
| C.F. | 2ndF [graph] C<br>Draws a cumulative frequency chart from current statistical data.<br>Available only in statistics graph mode. | No arguments. | 131 |
| C.P. | MENU D<br>Displays the process capability variables.<br>Available only in statistics graph mode. | No arguments. | 136 |
| CALC | MATH C<br>Displays the calculus menu.<br>Available only in real and graph mode. | No arguments. | 48 |





| | | | |
|---|---|---|---|
| CLEAR | 2ndF PLOT A<br>Clears the graph.<br>Available only in graphing and statistics graph mode. | No arguments. | 86 |
| ClrG | 2ndF COMMAND E 2<br>Clears graphics screen (doesn't affect text or change display modes).<br>Available only in program mode. | No arguments. | 97 |
| ClrT | 2ndF COMMAND E 1<br>Clears graphics screen (doesn't affect text or change display modes).<br>Available only in program mode. | No arguments. | 97 |
| CMPLX | SETUP H<br>Selects polar or rectangular complex coordinates. | Select item. | 27 |
| COMPLEX | MENU A 4<br>Enters complex mode to perform calculations with complex numbers. | No arguments. | 40 |
| conj | MATH E 6<br>Returns the complex conjugate.<br>Available only in complex mode. | conj *arg*<br>*arg* is a complex expression. | 74 |
| Connect | MENU C 1<br>Draws a vector graph.<br>Available only in graph mode. | No arguments. | 88 |
| COORD | SETUP E<br>Selects coordinate system. | Select item. | 24 |
| COPY | 2ndF OPTION C<br>Copies file.<br>Available in program, solver, and graph modes. | Select item. | 29 |
| cosh | MATH B 2<br>Hyperbolic cosine. | cosh *arg*<br>*arg* is an expression. | 43 |
| $\cosh^{-1}$ | MATH B 5<br>Inverse hyperbolic cosine. | $\cosh^{-1}$ *arg*<br>*arg* is an expression. | 43 |
| CTRST | 2ndF OPTION A<br>Adjusts the display contrast. | Press the plus key to darken the screen or the minus key to lighten it. | 28 |

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|---|---|---|---|
| Data | 2ndF COMMAND F 5<br>Enters a new statistical data point in the next available card.<br>Available only in stat programs. | Data[*arg1*, *arg2*, *arg3*]<br>*arg1*, *arg2*, and *arg3* are expressions.<br>*arg1* is an expression representing $x$.<br>*arg2* is an optional expression representing $y$ or $w$.<br>*arg3* is an optional expression representing $w$.<br>The arguments must be consistent with the selected statistics mode. | 97 |
| d/dx( | MATH C 1<br>Derivative function. Available only in real mode. | d/dx(*arg1*, *arg2*, *arg3*)<br>*arg1*, *arg2*, and *arg3* are expressions.<br>*arg1* is a function.<br>*arg2* is $x$, the value to calculate the derivative.<br>*arg3* is $\Delta x$, the change in $x$. | 48 |
| Decimal | SETUP G 1<br>Displays fractional results as decimal numbers. | No arguments. | 26 |
| DEFLT | RANGE MENU A<br>Selects the predefined default range for functions.<br>Available only in graph mode. | Select item. | 83 |
| Deg | SETUP B 1<br>Sets degrees as the angular mode. | No arguments. | 21 |
| DEL | MENU D (program mode)<br>Deletes program.<br>MENU G (graph mode)<br>Deletes graph.<br>MENU D (statistics mode)<br>Deletes cards or all statistics data. | Select item. | 31 |
| det | MATH E 6<br>Determinant of a square matrix.<br>Available only in matrix mode. | det mat *alpha*<br>*alpha* is a letter key. | 67 |





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| dim | MATH E 2<br>Sets the dimensions of a matrix.<br>You don't need to press ALPHA when selecting the matrix.<br>Available only in matrix mode.<br>*See also* [ and ]. | dim *alpha* [*arg1*, *arg2*]<br>*alpha* is a letter key representing the matrix.<br>*arg1* is an expression for the row.<br>*arg2* is an expression for the column. | 66 |
| DIRECT | 2ndF PLOT B 1<br>2ndF PLOT C 1<br>Accepts coordinates to plot a point or a line. | Enter points. | 86 |
| DispG | 2ndF COMMAND E 4<br>Shows the graphics screen.<br>Available only while editing a program. | No arguments. | 97 |
| DispT | 2ndF COMMAND E 3<br>Shows the text screen.<br>Available only while editing a program. | No arguments. | 97 |
| Dot | MENU C 2<br>Draws a dot graph.<br>Available only in graph mode. | No arguments. | 88 |
| DotGraph | 2ndF COMMAND D 3<br>Draws a non-connected dot graph.<br>Available only while editing a real program. | DotGraph *func1*, *func2*, *func3*, *func4*<br>*func1* is the function to graph.<br>*func2*, *func3*, and *func4* are optional additional functions to graph. | 97 |
| DRG | SETUP B<br>Selects angular unit settings. | Select item. | 21 |
| dx | MATH C 3<br>Marks the end of an integration equation.<br>*See also* ∫.<br>Available only in real mode. | ∫*arg1*, *arg2*, *arg3*, *arg4* dx<br>*arg1*, *arg2*, *arg3* and *arg4* are expressions.<br>*arg1* is a function.<br>*arg2* is the initial value.<br>*arg3* is the final value.<br>*arg4* (optional) is the number of subintervals. The calculator uses 100 if no subinterval is specified. | 50 |
| EDIT | ▶ B<br>Edits program.<br>SET UP F<br>Selects edit mode. | Select item. | 24 |

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| End | 2ndF COMMAND A 6<br>Marks the end of a program.<br>Available only while editing a program. | No arguments. | 98 |
| Eng | SETUP C 4<br>Selects engineering notation. | No arguments. | 22 |
| EQUATION | MENU B 1<br>Selects equation solver.<br>Available only in solver mode.<br>SET UP F 1<br>Selects equation edit mode. | No arguments. | 25 |
| EXP | RANGE MENU C<br>Selects the predefined range for exponential functions.<br>Available only in graph mode. | Select item. | 84 |
| FACTOR | ZOOM 4<br>Sets zoom factor.<br>Available only in graph mode. | Enter x and y factors. | 85 |
| Fill | 2ndF COMMAND D 8<br>Draws graph and fills the space between two functions.<br>Available only while editing a program. | Fill *func1*, *func2*<br>*func1* is the function to fill below.<br>*func2* is the function to fill above. | 98 |
| FILL | MENU A 5<br>Selects the fill options.<br>Available only in rectangular graph mode. | No arguments. | 88 |
| FIRST | MENU B 1<br>Goes to the first statistics card.<br>Available only in statistics mode. | No arguments. | 122 |
| Fix | SETUP C 2<br>Selects fixed point display. | No arguments. | 22 |
| Float Pt | SETUP C 1<br>Selects floating point display. | No arguments. | 22 |
| fpart | MATH A 4<br>Fractional part. | fpart *arg*<br>*arg* is an expression. | 46 |
| FREE | 2ndF PLOT B 2<br>2ndF PLOT C 2<br>Draws points or lines on a graph using the cursor. | Use the arrow keys to move the cursor. Press ENTER to draw a point. | 86 |





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| FSE | SETUP C<br>Displays notation menu. | Select item. | 22 |
| G(B.C.) | 2ndF COMMAND G 6<br>Draws a box chart from current statistical data. Statistics mode must be either XY or XYW.<br>Available only while editing a stat program. | No arguments. | 98 |
| G(B.L.) | 2ndF COMMAND G 2<br>Draws a broken-line chart from current statistical data.<br>Available only while editing a stat program. | No arguments. | 98 |
| G(C.F.) | 2ndF COMMAND G 3<br>Draws a cumulative frequency chart from current statistical data.<br>Available only while editing a stat program. | No arguments. | 98 |
| G(exP) | 2ndF COMMAND H 2<br>Draws the best fit exponential regression curve from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 99 |
| G(HIST) | 2ndF COMMAND G 1<br>Draws a histogram from current statistical data.<br>Available only while editing a stat program. | No arguments. | 99 |
| G(inV) | 2ndF COMMAND H 6<br>Draws the best fit inverse regression curve from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 99 |

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| G(line) | 2ndF COMMAND H 1<br>Draws the best fit linear regression line from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 99 |
| G(ln) | 2ndF COMMAND H 3<br>Draws the best fit natural logarithmic regression line from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 99 |
| G(log) | 2ndF COMMAND H 4<br>Draws the best fit logarithmic regression curve from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 99 |
| G(N.D.) | 2ndF COMMAND G 4<br>Draws a normal distribution curve from current statistical data.<br>Available only while editing a stat program. | No arguments. | 100 |
| G(pow) | 2ndF COMMAND H 5<br>Draws the best fit power regression curve from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 100 |
| G(S.D.) | 2ndF COMMAND G 5<br>Draws a scatter diagram from current statistical data.<br>Statistics mode must be XY or XYW.<br>Available only while editing a stat program. | No arguments. | 100 |





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| Gosub | 2ndF COMMAND B 4<br>Calls the specified subroutine.<br>Available only while editing a program.<br>*See also* Label and Return. | Gosub *str*<br>*str* is the label that marks the subroutine. | 100 |
| Goto | 2ndF COMMAND B 2<br>Jumps to the specified label.<br>Available only while editing a program.<br>*See also* Label and If. | Goto *str*<br>*str* is the label that marks the location to go to. | 100 |
| GRAPH | 2ndF COMMAND D<br>Displays graphing program commands.<br>Available only while editing real or stat program.<br>2ndF COMMAND D 1<br>Draws a graph.<br>Available only while editing a real program. | Select item.<br><br>Graph *func1*, *func2*, *func3*, *func4*<br>*func1* is the function to graph.<br>*func2*, *func3*, and *func4* are optional additional functions to graph. | 100 |
| GRAPHIC | MENU B 3<br>Selects the graphic method for solving equations.<br>Available only in solver mode. | No arguments. | 143 |
| HIST | 2ndF ⌨ A<br>Draws a histogram of the current statistics data. | No arguments. | 129 |
| HYP | RANGE MENU E<br>Selects the predefined range for hyperbolic trigonometric functions.<br>Available only in graph mode. | Select item. | 84 |
| i | MATH E 1<br>Inserts i (the imaginary number).<br>Available only in complex mode. | No arguments. | 74 |
| If | 2ndF COMMAND B 3<br>Conditional branch.<br>*See also* <, >, <=, >=, ≠, =, and Goto. | If *conditional expression* Goto *str*<br>*conditional expression* contains tests such as <, >, =, and so on.<br>Goto is the only command that can follow an If statement.<br>*str* is the label that marks the location to go to. | 101 |

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| image | [MATH] [E] [4]<br>Imaginary portion.<br>Available only in complex mode.<br>*See also* real. | image *arg*<br>*arg* is a complex expression. | 74 |
| Improp | [SETUP] [G] [3]<br>Displays fractional results as improper fraction. | No arguments. | 26 |
| IN | [ZOOM] [2]<br>Magnifies graph.<br>Available only in the graphing modes. | No arguments. | 85 |
| INEQ | [2ndF] [COMMAND] [C]<br>Displays program inequality commands.<br>Availables in program mode only. | Select item. | 101 |
| Input | [2ndF] [COMMAND] [A] [3]<br>Input number.<br>Available only while editing a program. | Input *str*<br>*str* is a local or global variable. | 101 |
| int | [MATH] [A] [2]<br>Integer value. | int *arg*<br>*arg* is an expression. | 46 |
| INTERSEC | [2ndF] [JUMP] [A] [1]<br>Move to the intersection of two functions.<br>Available only in graph mode. | No arguments. | 85 |
| ipart | [MATH] [A] [3]<br>Integer part. | ipart *arg*<br>*arg* is an expression. | 46 |
| Label | [2ndF] [COMMAND] [B] [1]<br>Marks a destination point for branch statements.<br>Available only while editing a program.<br>*See also* Goto, Gosub, and If. | Label *str*<br>*str* is a string of up to ten (eight for EL-9200) characters. | 102 |
| LAST | [MENU] [B] [2]<br>Goes to the last statistics card.<br>Available only in statistics mode. | No arguments. | 122 |
| LIMIT | [MENU] [C]<br>Sets limit on statistics graph.<br>Available only in statistics graph mode. | Select item. | 136 |





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| Line | [2ndF] [COMMAND] [D] [7]<br>Draws line from coordinates $x_1,y_1$ to $x_2,y_2$.<br>Available only while editing real and stat programs. | Line *arg1*, *arg2*, *arg3*, *arg4*<br>*arg1*, *arg2*, *arg3*, and *arg4* are expressions for the coordinates $x_1$, $y_1$, $x_2$, and $y_2$, respectively. | 87 |
| LINK | [2ndF] [OPTION] [G]<br>Sends data to or receives information from a cassette recorder or another calculator. (EL-9300 only) | No arguments. | 33 |
| LIST | [2ndF] [OPTION] [F] [3]<br>Prints a file.<br>Available in program, graph, and solver mode. (EL-9300 only) | Select item. | 33 |
| LOAD | [MENU] [E]<br>Retrieves previously saved graph.<br>Available only in graph mode.<br>[MENU] [C]<br>Retrieves previously saved equation.<br>Available only in solver mode. | Select item. | 34<br>147 |
| M.CHK | [2ndF] [OPTION] [B]<br>Displays memory usage. | No arguments. | 28 |
| MASK OFF | Display card, then press [MENU] [C] [2]<br>Unmasks a statistics data card.<br>Available only in statistics mode. | No arguments. | 123 |
| MASK ON | Display card, then press [MENU] [C] [1]<br>Masks a statistics data card.<br>Available only in statistics mode. | No arguments. | 123 |
| mat | [MATH] [E] [1]<br>Recalls matrix.<br>You don't need to press [ALPHA] when selecting the matrix.<br>Available only in matrix mode. | mat *alpha*<br>*alpha* is a letter key. | 65 |
| MATRIX | [MENU] [A] [3]<br>Enters matrix mode to define matrix elements and perform matrix calculations. | No arguments. | 40 |

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| MAX | 2ndF JUMP A 3<br>Jump to the maximum of a function.<br>Available only in graph mode. | No arguments. | 85 |
| mdf | MATH D 5<br>Modify function; replaces the stored value with the displayed value. | *value* mdf<br>*value* is a decimal. | 51 |
| MIN | 2ndF JUMP A 2<br>Jump to the minimum of a function.<br>Available only in graph mode. | No arguments. | 85 |
| Mixed | SETUP G 2<br>Displays fractional results as mixed numbers. | No arguments. | 26 |
| MOVE | 2ndF OPTION D<br>Moves a file.<br>Available only in graph, program, and solver modes. | Select item. | 30 |
| n | MATH E 6<br>Number of observations (previously entered in statistics mode).<br>Available only in real mode. | No arguments. | 52 |
| n! | MATH A 5<br>Factorial. | *arg* !<br>*arg* is an expression that evaluates to a positive integer. | 47 |
| NBASE | MENU A 2<br>Enters nbase mode to perform calculations in base 2, base 8, base 10, or base 16. Use MATH D to set the base.<br>Available only in calculation mode. | No arguments. | 40 |
| nCr | MATH A 6<br>Calculate the number of combinations (the number of different groups of *r* items that can be made out of *n* objects). | *arg*1 C *arg*2<br>*arg*1 and *arg*2 are expressions.<br>*arg*1 is *n*, the number of total items.<br>*arg*2 is *r*, the number of items you want in the smaller group.<br>n and r must be integers. | 47 |





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| N.D. | 2ndF ▭ D<br>Draws a normal distribution graph from current statistical data.<br>Available only in statistics graph mode. | No arguments. | 131 |
| neg | MATH E 4<br>Logical negate operation.<br>Available only in nbase mode. | neg *arg*<br>*arg* is an expression. | 58 |
| NEW | ▭ C<br>New program. | No arguments. | 91 |
| NEWTON | MENU B 2<br>Selects the newton method for solving equations.<br>Available only in solver mode. | No arguments. | 143 |
| not | MATH E 3<br>Logical NOT operation.<br>Available only in nbase mode. | not *arg*<br>*arg* is ~~expressions.~~ an expression | 57 |
| nPr | MATH A 7<br>Calculate the number of permutations (the number of different arrangements of *r* items that can be made out of *n* objects). | *arg*1 P *arg*2<br>*arg*1 and *arg*2 are expressions.<br>*arg*1 is *n*, the number of total items.<br>*arg*2 is *r*, the number of items you want in the smaller group.<br>n and r must be integers. | 47 |
| OFF | MENU C 3<br>Turns off the limits.<br>Available only in statistics graph mode. | No arguments. | 136 |
| OMEGA | MENU E ENTER<br>Displays the OMEGA conversion function.<br>Available only in statistics graph mode. | No arguments. | 137 |
| ON | MENU C 2<br>Turns on the limits.<br>Available only in statistics graph mode. | No arguments. | 136 |
| ONE DATA | MENU D 1<br>Deletes one data card.<br>Available only in statistics mode. | No arguments. | 123 |

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| ONE LINE | [SETUP] [F] [2]<br>Selects one line edit mode. | No arguments. | 25 |
| or | [MATH] [E] [2]<br>Logical OR operation.<br>Available only in nbase mode. | *arg1* or *arg2*<br>*arg1* and *arg2* are expressions. | 57 |
| OUT | [ZOOM] [3]<br>Reduces graph.<br>Available only in graphing modes. | No arguments. | 85 |
| Plot | [2ndF] [COMMAND] [D] [6]<br>Plots point at coordinates x,y.<br>Available only while editing real and stat programs. | Plot *arg1*, *arg2*<br>*arg1* and *arg2* are expressions for the coordinates x and y, respectively. | 102 |
| PLOT | [2ndF] [PLOT] [B]<br>Plots points on a graph.<br>Available only in graphing modes. | Select item. | 86 |
| PLOT1 | [MENU] [C]<br>Selects connected or dot graphs.<br>Available only in graph mode. | Select item. | 88 |
| PLOT2 | [MENU] [D]<br>Selects sequential or simultaneous graphs.<br>Available only in graph mode. | Select item. | 88 |
| POWER | [RANGE] [MENU] [B]<br>Selects the predefined range for power functions.<br>Available only in graph mode. | Select item. | 84 |
| Print | [2ndF] [COMMAND] [A] [1]<br>Prints characters.<br>Available only while editing a program. | Print "*str*<br>*str* is a string of characters.<br>Print *arg*<br>*arg* is an expression. | 102 |
| PRINT | [2ndF] [OPTION] [F]<br>Sends information to printer. | Select item. | 32 |
| PROG | [2ndF] [COMMAND] [A]<br>Lists programming commands. | Select item. | 29 |
| r | [MATH] [G] [3]<br>Correlation coefficient.<br>Available in real mode only. | No arguments. | 54 |
| Rad | [SETUP] [B] [2]<br>Selects radians. | No arguments. | 42 |





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| random | [MATH] [A] [8]<br>Generates a random number (between 0 and 1). | No arguments. | 47 |
| Range | [2ndF] [COMMAND] [D] [4]<br>Sets range for the graphing screen.<br>Available only while editing real and stat programs. | range *arg1*, *arg2*, *arg3*, *arg4*, *arg5*, *arg6*, *arg7*<br>*arg1*, *arg2*, and *arg3* are expressions for *xmin*, *xmax*, and *xscale*, respectively.<br>*arg4*, *arg5*, and *arg6* are expressions for *ymin*, *ymax*, and *yscale*, respectively. The *y* range is required even if the Auto Graph function is used.<br>*arg7* is an optional expression for the number of data points for statistics graphs. | 103 |
| real | [MATH] [E] [3]<br>Real portion.<br>Available only in complex mode.<br>*See also* image. | real *arg*<br>*arg* is a complex expression. | 74 |
| REAL | [MENU] [A] [1]<br>Enters real mode to perform calculations with real numbers. | No arguments. | 40 |
| RECIV | [2ndF] [OPTION] [G] [ENTER] [C]<br>Receives data into the current mode from a cassette recorder or another calculator. Data must be saved and loaded in the same mode. (EL-9300 only.) | No arguments. | 34 |
| REG | [MATH] [G]<br>Displays regression variables.<br>Available only in real mode.<br>[MENU] [A]<br>Displays regression values<br>Available only in statistics graph mode. | Select item.<br><br>No arguments. | 53<br><br>120 |
| REG. | [2ndF] [▭] [F]<br>Displays regression graphs.<br>Available only in statistics graph mode. | Select item. | 133 |

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| REG.G | [2ndF] [COMMAND] [H]<br>Displays program regression graphing commands.<br>Availables in stat program mode only. | Select item. | 99 |
| RESTR | [2ndF] [OPTION] [G] [ENTER] [E]<br>Restores a back-up from tape. (EL-9300 only.)<br>Tape interface must be connected. | No arguments. | 35 |
| Rem | [2ndF] [COMMAND] [A] [5]<br>Remarks<br>The Rem statement has no effect on program operation.<br>Available only while editing a program. | Rem *str*<br>*str* is an expression. | 103 |
| Return | [2ndF] [COMMAND] [B] [5]<br>Ends subroutine and resumes operation at the line following the Gosub statement that called the subroutine.<br>Available only while editing a program. | No arguments. | 103 |
| row m.p. | [MATH] [F] [4]<br>Multiplies row by scalar, adds to second row and stores result in second row.<br>Available only in matrix mode. | row m.p.(*arg1*, *alpha*, *arg2*, *arg3*)<br>*arg1* is an expression for the multiplier.<br>*alpha* is a letter key representing the matrix.<br>*arg2* is an expression for the first row.<br>*arg3* is an expression for the second row. | 71 |
| row mult | [MATH] [F] [3]<br>Multiplies row by scalar.<br>Available only in matrix mode. | row mult(*arg1*, *alpha*, *arg2*)<br>*arg1* is an expression for the multiplier.<br>*alpha* is a letter key representing the matrix.<br>*arg2* is an expression for the row. | 70 |
| row plus | [MATH] [F] [2]<br>Adds two rows and stores result in second row.<br>Available only in matrix mode. | row plus(*alpha*, *arg1*, *arg2*)<br>*alpha* is a letter key representing the matrix.<br>*arg1* is an expression for the first row.<br>*arg2* is an expression for the second row. | 69 |





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| row swap | [MATH] [F] [1]<br>Switches two rows of matrix.<br>Available only in matrix mode. | row swap(*alpha*, *arg1*, *arg2*)<br>*alpha* is a letter key representing the matrix.<br>*arg1* is an expression for a row.<br>*arg2* is an expression for a row. | 68 |
| RUN | [▶] [A]<br>Runs program. | Select item. | 91 |
| RΘ | [SETUP] [E] [2]<br>Sets polar coordinates in graph mode. | No arguments. | 24 |
| R∠Θ | [SETUP] [H] [2]<br>Sets polar coordinates in complex mode. | No arguments. | 27 |
| S.ALL | [2ndF] [OPTION] [G] [ENTER] [B]<br>Sends all data from the current mode to a cassette recorder or another calculator. (EL-9300 only) | No arguments. | 34 |
| SAVE | [MENU] [F]<br>Saves graph function.<br>Available only in graph mode.<br>[MENU] [D]<br>Saves equation.<br>Available only in solver mode.<br>[2ndF] [OPTION] [G] [ENTER] [A]<br>Saves files to a cassette. | No arguments. | 89<br>147<br>34 |
| SCALE | [MENU] [B]<br>Displays scale.<br>Available only in statistics graph mode. | Select item. | 136 |
| SCREEN*1 | [2ndF] [OPTION] [F] [1]<br>Selects normal printout. (EL-9300 only) | No arguments. | 32 |
| SCREEN*2 | [2ndF] [OPTION] [F] [2]<br>Selects sideways printout. (EL-9300 only) | No arguments. | 32 |
| SCRN | [MENU] [A]<br>Jumps to equations and functions.<br>Available only in graph mode.<br>[2ndF] [COMMAND] [E]<br>Displays screen commands.<br>Available in program mode only. | Select item. | 88 |

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| S.D. | 2ndF [graph] E<br>Draws a scatter diagram from current statistical data.<br>Available only in statistics graph mode. | No arguments. | 132 |
| SEND | 2ndF OPTION G ENTER A<br>Sends specified data from current mode to a cassette recorder or another calculator. (EL-9300 only) | No arguments. | 33 |
| Sequence | MENU D 1<br>Selects sequential graphing.<br>Available only in graph mode. | No arguments. | 88 |
| Set | MENU C 1<br>Sets upper and lower limit values.<br>Available only in statistics graph mode. | Enter values. | 136 |
| Simul | MENU D 2<br>Selects simultaneous graphing.<br>Available only in graph mode. | No arguments. | 88 |
| sinh | MATH B 1<br>Hyperbolic sine. | sinh *arg*<br>*arg* is an expression. | 43 |
| $\sinh^{-1}$ | MATH B 4<br>Inverse hyperbolic sine. | $\sinh^{-1}$ *arg*<br>*arg* is an expression. | 43 |
| St | 2ndF COMMAND F 6<br>Recalls existing statistical value.<br>Available only in stat programs. | St[*arg1*, *arg2*]<br>*arg1* is an expression that results in 1, 2, or 3, specifying the x, y, or w variable.<br>*arg2* is an expression specifying the data card number. | 104 |
| ST.G | 2ndF COMMAND G<br>Displays program statistical graphing commands.<br>Availables in stat program mode only. | Select item. | 99 |
| STAT | 2ndF COMMAND F<br>Displays program statistical commands.<br>Availables in stat program mode only. | Select item. | 104 |





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| Stat X | 2ndF COMMAND F 1<br>Selects one-variable statistics mode.<br>Erases all data stored in the statistics cards.<br>Available only while editing a stat program. | No arguments. | 104 |
| Stat XW | 2ndF COMMAND F 2<br>Selects weighted one-variable statistics mode.<br>Erases all data stored in the statistics cards.<br>Available only while editing a stat program. | No arguments. | 105 |
| Stat XY | 2ndF COMMAND F 3<br>Selects two-variable statistics mode.<br>Erases all data stored in the statistics cards.<br>Available only while editing a stat program. | No arguments. | 105 |
| Stat XYW | 2ndF COMMAND F 4<br>Selects weighted two-variable statistics mode.<br>Erases all data stored in the statistics cards.<br>Available only while editing a stat program. | No arguments. | 105 |
| $s_x$ | MATH E 2<br>Sample standard deviation of x data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |
| $\Sigma x$ | MATH E 4<br>Sum of x data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |
| $\Sigma x^2$ | MATH E 5<br>Sum of the squares of x data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |

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| Σxy | [MATH] [F] [6]<br>Sum of the products of the xy data pairs (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| sy | [MATH] [F] [2]<br>Sample standard deviation of y data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| Σy | [MATH] [F] [4]<br>Sum of y data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| Σy² | [MATH] [F] [5]<br>Sum of the squares of y data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| TAB | [SETUP] [D]<br>Sets the number of decimal places. | Select item. | 23 |
| tanh | [MATH] [B] [3]<br>Hyperbolic tangent. | tanh *arg*<br>*arg* is an expression | 43 |
| $\tanh^{-1}$ | [MATH] [B] [6]<br>Inverse hyperbolic tangent. | $\tanh^{-1}$ *arg*<br>*arg* is an expression | 43 |
| TRIG | [RANGE] [MENU] [D]<br>Selects the predefined range for trigonometric functions.<br>Available only in graph mode. | Select item. | 84 |
| trns | [MATH] [E] [5]<br>Transposes matrix.<br>Available only in matrix mode. | trns mat *alpha*<br>*alpha* is a letter key. | 66 |
| VAR | [MATH] [E]<br>Displays functions available for graphing.<br>Available only in graph mode. | Select item. | 88 |
| VRIFY | [2ndF] [OPTION] [G] [ENTER] [C]<br>Verifies that a file on cassette is the same as one in the calculator. (EL-9300 only)<br>Available only when the cassette interface is connected. | Select item. | 35 |





| | | | |
|---|---|---|---|
| Wait | [2ndF] [COMMAND] [A] [4]<br>Waits for a specified number of seconds or until a key is pressed.<br>Available only while editing a program. | Wait *arg*<br>*arg* is an expression. | 105 |
| X ASCEND | [MENU] [E] [1]<br>Sorts statistics cards in ascending order based on the *x* value.<br>Available only in statistics mode. | No arguments. | 124 |
| X DESCEN | [MENU] [E] [2]<br>Sorts statistics cards in descending order based on the *x* value.<br>Available only in statistics mode. | No arguments. | 124 |
| X INCPT | [2ndF] [JUMP] [A] [4]<br>Moves to the x intercept of selected item.<br>Available only in graph mode. | Select item. | 85 |
| X-VARS | [MENU] [A] [1]<br>Displays the *x* variable statistics.<br>Available only in statistics mode. | No arguments. | 118 |
| x' | [MATH] [G] [4]<br>Estimated value of *x*, based on linear regression.<br>Available in real mode only. | *arg* x' | 54 |
| xmax | [MATH] [E] [8]<br>Maximum *x* value from data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |
| xmin | [MATH] [E] [7]<br>Minimum *x* value from data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 52 |
| xnor | [MATH] [E] [6]<br>Logical XNOR operation.<br>Available only in nbase mode. | *arg1* xnor *arg2*<br>*arg1* and *arg2* are expressions. | 59 |

| | | | |
|---|---|---|---|
| xor | [MATH] [E] [5]<br>Logical XOR operation.<br>Available only in nbase mode. | *arg1* xor *arg2*<br>*arg1* and *arg2* are expressions. | 58 |
| X+Yi | [SETUP] [H] [1]<br>Sets rectangular coordinates in complex mode. | No arguments. | 27 |
| XYT | [SETUP] [E] [3]<br>Selects parametric equations. | No arguments. | 24 |
| Y ASCEND | [MENU] [E] [3]<br>Sorts statistics cards in ascending order based on the *y* value.<br>Available only in statistics mode. | No arguments. | 124 |
| Y DESCEN | [MENU] [E] [4]<br>Sorts statistics cards in descending order based on the *y* value.<br>Available only in statistics mode. | No arguments. | 124 |
| Y INCPT | [2ndF] [JUMP] [A] [5]<br>Moves to the y intercept of selected item.<br>Available only in graph mode. | Select item. | 85 |
| Y-VARS | [MENU] [A] [2]<br>Displays the *x* variable statistics.<br>Available only in statistics mode. | No arguments. | 119 |
| y' | [MATH] [G] [5]<br>Estimated value of y, based on linear regression.<br>Available in real mode only. | *arg y* | 54 |
| Y' | [MENU] [B]<br>Determines derivative of the graphed function while using the trace function.<br>Available only in graph mode. | Select item. | 88 |
| Y1 | [MATH] [E] [1]<br>Selects function Y1 for graphing.<br>Available only in graph mode. | No arguments. | 88 |





| | | | |
|---|---|---|---|
| Y2 | [MATH] [E] [2]<br>Selects function Y2 for graphing.<br>Available only in graph mode. | No arguments. | 88 |
| Y3 | [MATH] [E] [3]<br>Selects function Y3 for graphing.<br>Available only in graph mode. | No arguments. | 88 |
| Y4 | [MATH] [E] [4]<br>Selects function Y4 for graphing.<br>Available only in graph mode. | No arguments. | 88 |
| ymax | [MATH] [F] [8]<br>Maximum *y* value from data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| ymin | [MATH] [F] [7]<br>Minimum *y* value from data (previously entered in statistics mode).<br>Available in real mode only. | No arguments. | 53 |
| Zoom | [2ndF] [COMMAND] [D] [5]<br>Adjusts the range of a graph. You must draw a graph before zooming.<br>Available only while editing a real or stat program. | zoom *arg1*, *arg2*<br>*arg1* is an expression for the zoom factor, $1/arg1$.<br>*arg2* is an optional expression for the *y* zoom factor (in this case, *arg1* is the *x* zoom factor). | 84 |

# APPENDIX D:
# Technical Data

This appendix describes calculation accuracy and memory usage.

## Accuracy

Entires and the four basic arithmetic operations, first and second operands, and calculation results must be within:

$\pm 1 \times 10^{-99}$ to $9.999999999 \times 10^{99}$ and 0.

Note The calculator regards absolute values of a numeric entry (or results of a calculation) less than $1 \times 10^{-99}$ as 0 (zero).

Scientific and special functions:

| Function | Dynamic range |
|---|---|
| SINx<br>COSx<br>TANx | DEG: $\|x\| < 1 \times 10^{10}$<br>RAD: $\|x\| < \frac{\pi}{180} \times 10^{10}$<br>GRAD: $\|x\| < \frac{10}{9} \times 10^{10}$<br>With TANX, however, an error occurs in the following cases:<br>DEG: $\|x\| = 90(2n-1)$<br>RAD: $\|x\| = \frac{\pi}{2}(2n-1)$<br>GRAD: $\|x\| = 100(2n-1)$ (n=integer) |
| $SIN^{-1}x$<br>$COS^{-1}x$ | $-1 \leq x \leq 1$ |

| | |
|---|---|
| $TAN^{-1}x$ | $\|x\| < 1x10^{100}$ |
| LNx<br>LOGx | $1x10^{-99} \le x < 1x10^{100}$ |
| $e^x$ | $-1x10^{100} < x < 230.2585093$ |
| $10^x$ | $-1x10^{100} < x < 100$ |
| $a^b$ | a > 0:<br>$-1x10^{100} < b \text{ LOG } a < 100$<br>a=0:<br>$0 < b < 1x10^{100}$<br>a < 0:<br>where b: integer or 1/b: odd number(b≠0)<br>$-1x10^{100} < b \text{ LOG } \|a\| < 100$ |
| $a\sqrt{b}$ | b > 0:<br>$-1x10^{100} < \frac{1}{a} \text{ LOG } b < 100 \quad (a \neq 0)$<br>b=0:<br>$0 < b < 1x10^{100}$<br>b < 0:<br>where a is an integer or 1/a is an odd number(a≠0)<br>$-1x10^{100} < \frac{1}{a} \text{ LOG } \|b\| < 100$ |
| SINHx<br>COSHx<br>TANHx | $-230.2585093 < x < 230.2585093$ |
| $SINH^{-1}x$ | $\|x\| < 1 \times 10^{50}$ |
| $COSH^{-1}x$ | $1 \le x < 1 \times 10^{50}$ |





| | |
|---|---|
| $TANH^{-1}x$ | $\|x\| < 1$ |
| $\sqrt{x}$ | $0 \le x < 1 \times 10^{100}$ |
| $x^2$ | $\|x\| < 1 \times 10^{50}$ |
| $x^{-1}$ | $\|x\| < 1 \times 10^{100} (x \neq 0)$ |
| n! | $0 \le n \le 69$ (n: integer) |
| nCr<br>nPr | $0 \le r \le n \le 69$. (r,n: integer) |
| Conversions: | converted result: |
| →dec | DEC: $\|x\| \le 9999999999$ |
| →bin | BIN: $1000000000000000 \le x \le 1111111111111111$ |
| →oct | $0 \le x \le 0111111111111111$ |
| →hex | OCT: $4000000000 \le x \le 7777777777$<br>$0 \le x \le 3777777777$<br>HEX: FDABF41C01 ≤ x ≤ FFFFFFFFFF<br>$0 \le x \le 2540BE3FF$ |
| Logical Operations:<br>not | BIN: $1000000000000000 \le x \le 1111111111111111$<br>$0 \le x \le 0111111111111111$<br>OCT: $4000000000 \le x \le 7777777777$<br>$0 \le x \le 3777777777$<br>HEX: FDABF41C01 ≤ x ≤ FFFFFFFFFF<br>$0 \le x \le 2540BE3FE$ |

| | |
|---|---|
| neg | BIN: $1000000000000001 \le x \le 1111111111111111$<br>$0 \le x \le 0111111111111111$<br>OCT: $4000000001 \le x \le 7777777777$<br>$0 \le x \le 3777777777$<br>HEX: $FDABF41C01 \le x \le FFFFFFFFFF$<br>$0 \le x \le 2540BE3FF$ |
| All other logical operations | same as NOT and NEG |
| →rθ | $\lvert x \rvert < 1 \times 10^{100}$ $\lvert y \rvert < 1 \times 10^{100}$<br>$\sqrt{x^2+y^2} < 1 \times 10^{100}$<br>$\lvert \frac{y}{x} \rvert < 1 \times 10^{100}$ |
| →xy | $\lvert r \rvert < 1 \times 10^{100}$<br>Same as trigonometric functions apply to the angle. |
| →dms<br>→deg | $\lvert x \rvert < 1 \times 10^{100}$ |
| Statistics mode | $\lvert x \rvert < 1 \times 10^{50}$<br>$\lvert y \rvert < 1 \times 10^{50}$<br>$\lvert \Sigma x \rvert < 1 \times 10^{100}$<br>$\Sigma x^2 < 1 \times 10^{100}$<br>$\lvert \Sigma y \rvert < 1 \times 10^{100}$<br>$\Sigma y^2 < 1 \times 10^{100}$<br>$\lvert \Sigma xy \rvert < 1 \times 10^{100}$<br>$\lvert n \rvert < 1 \times 10^{100}$ |
| $\bar{x}$ | $n \neq 0$ |





| | |
|---|---|
| sx | $n > 1$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$0 \le \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1} < 1 \times 10^{100}$ |
| σx | $n > 0$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$0 \le \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n} < 1 \times 10^{100}$ |
| $\bar{y}$<br>sy<br>σy | Same as $\bar{x}$, sx, σx |
| r | $n > 0$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$\lvert \Sigma y \rvert < 1 \times 10^{50}$<br>$0 < (\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n}) < 1 \times 10^{100}$<br>$\lvert \Sigma xy - \frac{\Sigma x \Sigma y}{n} \rvert < 1 \times 10^{100}$<br>$\left\lvert \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\sqrt{(\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n})}} \right\rvert < 1 \times 10^{100}$ |

| | |
|---|---|
| b | $n > 0$<br>$\lvert \Sigma x \rvert < 1 \times 10^{50}$<br>$\lvert (\Sigma x)(\Sigma y) \rvert < 1 \times 10^{100}$<br>$0 < \left\lvert \Sigma x^2 - \frac{(\Sigma x)^2}{n} \right\rvert < 1 \times 10^{100}$<br>$\lvert \Sigma xy - \frac{\Sigma x \Sigma y}{n} \rvert < 1 \times 10^{100}$<br>$\left\lvert \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}} \right\rvert < 1 \times 10^{100}$ |
| a | same as b except the following:<br>$\lvert b\bar{x} \rvert < 1 \times 10^{100}$<br>$\lvert \bar{y} - b\bar{x} \rvert < 1 \times 10^{100}$ |
| y′ | $\lvert bx \rvert < 1 \times 10^{100}$<br>$\lvert a + bx \rvert < 1 \times 10^{100}$ |
| x′ | $\lvert y - a \rvert < 1 \times 10^{100}$<br>$\lvert \frac{y-a}{b} \rvert < 1 \times 10^{100}$ |

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 the mantissa in scientific notation) within the above calculation ranges. When calculating SINHx and TANHx, x is a singular point when it is 0(zero). Near this point, errors accumulate, reducing the accuracy.





Complex Functions:

| Function | Dynamic accuracy |
|---|---|
| SIN (x+yi) | $\lvert x \rvert < 230$ |
| COS (x+yi) | $\lvert y \rvert < 230$ |
| SINH(x+yi) | |
| COSH(x+yi) | |
| TAN(x+yi) | $\lvert x \rvert < 115$ |
| TANH(x+yi) | $\lvert y \rvert < 115$ |
| $SIN^{-1}$ (x+yi) | $\lvert x \rvert < 10^{25}$ |
| $COS^{-1}$ (x+yi) | $\lvert y \rvert < 10^{25}$ |
| $SINH^{-1}$ (x+yi) | |
| $COSH^{-1}$ (x+yi) | |
| $TAN^{-1}$ (x+yi) | $\lvert x \rvert < 10^{50}$ |
| $TANH^{-1}$ (x+yi) | $\lvert y \rvert < 10^{50}$ |
| $\frac{1}{x+yi}$ | $\lvert x \rvert < 10^{50}$<br>$\lvert y \rvert < 10^{50}$ $(x+yi \neq 0)$ |
| $(x+yi)^2$ | $\lvert x \rvert < 10^{50}$<br>$\lvert y \rvert < 10^{50}$<br>$\lvert xy \rvert < 5 \times 10^{99}$ |
| LOG (x+yi) | $\lvert x \rvert < 10^{50}$ |
| LN(x+yi) | $\lvert y \rvert < 10^{50}$ |
| $\sqrt{x+yi}$ | $\lvert \frac{y}{x} \rvert < 10^{100}$ |

| | |
|---|---|
| $10^{(x+yi)}$ | $\|x\| < 100$, $\|y\| < 100$ |
| $e^{(x+yi)}$ | $\|x\| < 230$, $\|y\| < 230$ |
| $(x+yi)^{(a+bi)}$ | $\|x\| < 10^{50}$<br>$\|y\| < 10^{50}$<br>$\|a\| < 10^{100}$<br>$\|b\| < 10^{100}$ |

In complex number mode, the calculation error is normally ±1 at the eigth digit of the mantissa.

Calculations in rθ mode may generate a large calculation error.

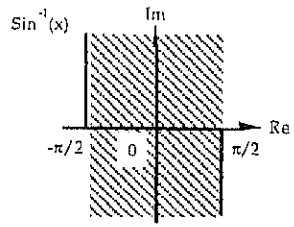
The values near singularities cause large calculation errors.

In complex or rθ mode calculation speed is slower.

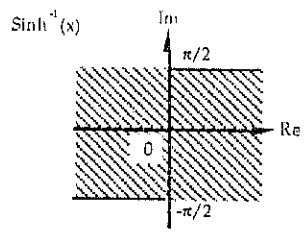




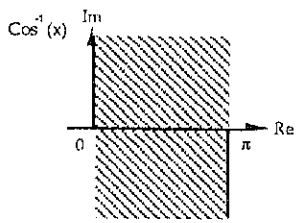
The calculator presets the range of solutions as follows:



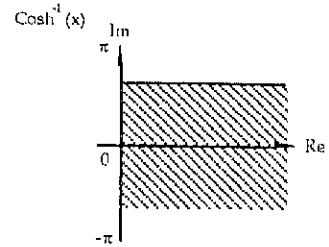

$-\pi/2 \le Re \le \pi/2$



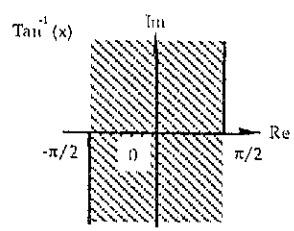

$-\pi/2 \le Im \le \pi/2$



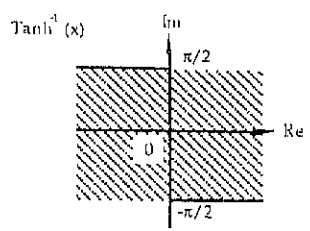

$0 \le Re \le \pi$




$Re \ge 0$
$-\pi < Im \le \pi$




$-\pi/2 \le Re \le \pi/2$




$-\pi/2 \le Im \le \pi/2$

In the above graphs, Re is real and Im is imaginary.

## Memory usage

This section describes how the calculator uses memory in one line edit mode.

Note: Equation edit mode requires more memory due to the stored display commands.

### Program mode

An empty program uses 35 bytes of memory.

Each line in a program uses 3 bytes plus the number of characters or commands on the line (each character or command uses 1 byte). For example, the two-line program shown below contains 6 characters and uses 45 bytes.

| | |
|---|---|
| Program | 35 bytes |
| Print A | 3 bytes+2 bytes |
| Print B | 3 bytes+2 bytes |

35+5+5=45 bytes total.

### Matrix mode

Each matrix uses 6 bytes plus 9 times the number of elements.

### Graph mode

Each stored graph function uses 169 bytes plus the number of letters or commands. For example, a Y1=sin x uses 169+2 bytes.

### Solver mode

Each stored solver equation uses 35 bytes plus the number of characters or commands.



# APPENDIX E: Specifications

Model: EL-9200/EL-9300

Display type: 16 columns X 8 rows (dot matrix character: 5 X 7 dots)

Calculation system: D.A.L.(Direct Algebraic Logic) result display (with priority judging function)

Number of display digits: 10-digit mantissa and 2-digit exponent

Number of internal calculation digits: 14-digit mantissa (Complex mode has 8-digit mantissas)

Display system: designation of numeric display system, calculation system, answer display system, and answer display system for complex numbers.

Calculation functions: Manual calculation (four basic arithmetic operations, calculations with parentheses, memory calculations, function calculations, numeric differential and numeric integral calculations, and coordinate conversion), binary/octal/decimal/hexadecimal conversion, logical operations, matrix operations, complex number calculations, complex variable function calculation (only in EL-9300), statistical calculations, etc.

Graphic functions: Rectangular coordinate graph, polar coordinate graph, parametric graph, range setting, automatic range setting (auto scaling), graph drawing, tracing, jumping, zooming, plotting, filling, graph formula storage, etc.

Program function: Conditional branch instructions, subroutines, graph instructions, etc.

Statistical input function: One-variable statistics input, two-variable statistics input, storage, deletion, weighted data input, data masking, sorting, etc.

Statistical graph function: Drawing of various statistical graphs, range setting, automatic range setting (auto scaling), process capability calculations, omega conversion, etc.

Solver function(only in EL-9300): Equation solver system; Formula syntactic analysis, Newton method analysis, graphic analysis, storage of solver equations, etc.

Options:Display contrast control, remaining memory check, data copy, data move, deletion, etc.

EL-9300 only: Display printing, data printing, and data communication.

Set up functions: Designation of angular unit, number display system, coordinate system for graph, calculation system, answer display system, and answer display system for complex numbers.

Memory capacity: EL-9300; 32 Kbytes (user area; 23,064 bytes) EL-9200; 8 Kbytes (user area; 1,800 bytes)

Power supply: 6V-(DC); AAA type dry battery X 4 (for operation) 3V-(DC); lithium battery (CR2032) X 1 (for memory backup; only in EL-9300)

Auto power off: Approximately 7 minutes

Power consumption: 0.1 W

Operating temperature: 0°C to 40°C (32°F to 104°F)

Operating time: Approximately 140 hours (at 20°C (68°F) when each hour is 5 minutes of continuous operation and 55 minutes of display).

For memory backup (only in EL-9300); Approximately 5 years (at 20°C (68°F) with prompt replacement of AAA batteries when needed).

Note: These values may vary with the type of batteries and method of use.

Dimensions: 80 (W) X 182 (D) X 19.5 (H) mm (3 5/32 X 7 5/32 X 25/32 inch) (without hard case)

Weight: EL-9200 : 210g (0.46 lb.), EL-9300 : 220g (0.49 lb.) (including batteries, not including hard case)

Accessories: 4 AAA type batteries (included), 1 lithium battery (only installed in EL-9300) and Operation Manual.



# APPENDIX F:
# Function Count

The following tables list all of the EL-9300 calculator functions:

**Basic functions**

| Operation | Type | Total |
|---|---|---|
| Function buffer | 32 functions, 14 numbers | 46 |
| Arithmetic calculations | +, −, ×, ÷, (-), Exp | 6 |
| Memories | A-Z, θ | 27 |
| Memory functions | STO, RCL | 2 |
| Last answer function | Ans | 1 |
| Play back function | Play back | 1 |
| Menu selection | Menu card | 1 |
| Editor function | CL, CA, DEL, BS, INS, ◄, ►, ▲, ▼ | 9 |
| Equation editor | Fraction, Exponent, Root, Absolute, Integrate symbol, Parentheses | 6 |
| Angle mode setup | DEG, RAD, GRAD | 3 |
| Display format setup | Floating point, Fix, Sci, Eng/TAB 0-9 | 14 |
| Graphing mode setup | xy, rθ, xyt | 3 |
| Editor mode | Equation, One line | 2 |
| Display answer format | Decimal, Mixed, Improper | 3 |
| Complex answer format | x+yi, r∠θ | 2 |

## Calculation mode

| Operation | Type | Total |
|---|---|---|
| Trigonometric (in DEG, RAD, GRAD) | sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$ | 18 |
| Hyperbolic | sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$ | 6 |
| Exponential and logarithmic | $e^x$, $10^x$, ln, log | 4 |
| Power | $a^b$, $x^2$, $x^{-1}$, $\sqrt[a]{\ }$, $\sqrt{\ }$ | 5 |
| Angle unit conversion | →dms, →deg | 2 |
| Coordinate conversion | →xy, →rθ | 2 |
| Factorial, permutation, combination | n!, nPr, nCr | 3 |
| Absolute, integer part, fractional part, integer | Abs, Ipart, Fpart, Int | 4 |
| Round | rndf | 1 |
| Numerical integration | ∫dx, a~b, n | 3 |
| Numerical differentiation | d/dx, x, Δx | 3 |
| Random number generation | random | 1 |
| Pi | π | 1 |
| 1-variable statistics | $\bar{x}$, sx, σx, Σx, $\Sigma x^2$, n, Xmax, Xmin | 8 |
| 2-variable statistics | $\bar{y}$, sy, σy, Σy, $\Sigma y^2$, Σxy, Ymax, Ymin | 8 |
| Regression analysis | a, b, r(linear) | 3 |
| Estimation | x', y' | 2 |
| Complex calculations | x+yi, r∠θ, (x+yi)÷(r∠θ) | 3 |
| Complex functions | sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, log, ln, $10^x$, $e^x$, $a^b$, $\sqrt[a]{\ }$, $\sqrt{\ }$, $x^{-1}$, $x^2$, abs | 22 |
| Real part, imaginary part, angle, conjugate | Real, Image, Arg, Conj | 4 |
| N base | →bin, →oct, →hex, →dec | 4 |
| Conversion | bin↔oct↔dec↔hex | 12 |





| | | |
|---|---|---|
| Logical operation | And, Or, Not, Neg, Xor, Xnor | 6 |
| Matrix memories | Mat A – Mat Z | 26 |
| Transposition, determinant, inverse, power, negation | Trns, Det, $x^{-1}$, $x^2$, (-) | 5 |
| Row operations | Row swap, Row plus, Row mult, Row m.p. | 4 |
| Setting matrix size | Dim | 1 |

## Solver mode

| Operation | Type | Total |
|---|---|---|
| Solving method | Equation, newton, graphic | 3 |
| Save solve equation | 99 equations | 1 |

## Statistics mode

| Operation | Type | Total |
|---|---|---|
| 1-variable statistics | $\bar{x}$, sx, σx, Σx, $\Sigma x^2$, n, Xmax, Xmin | — |
| 2-variable statistics | $\bar{y}$, sy, σy, Σy, $\Sigma y^2$, Σxy, Ymax, Ymin | — |
| Regression analysis | a, b, r(linear) | — |
| Estimation | x', y' | — |
| Data format | 1-variable with weight, 2-variable with weight | 4 |
| Select data card | First, Last, Any card | 3 |
| Data sorting | X-ascend/descend, Y-ascend/descend | 4 |
| Delete | 1 data, All data | 2 |
| Mask | On/Off | 1 |
| Save statistics data | A-Z (common use with matrices data) | 1 |

| | | |
|---|---|---|
| Statistical graphs | Hist, B.L., C.F., N.D., S.D., B.C. | 6 |
| Regression curve | a+bX, $axe^{bX}$, a+bxlnX, a+bxlogX, $aX^b$, a+bx$^{-1}$ | 6 |
| Statistics graph y-axis | Linear, % | 2 |
| Process capability | Limit setting, On/Off, Cpk, Cp | 4 |
| Omega conversion | y, p | 2 |
| Auto scaling | x-y axis auto scaling | 1 |

## Graphics mode

| Operation | Type | Total |
|---|---|---|
| Rectangular, Polar, Parametric | xy, rθ, xyt | — |
| Draw type | Graph, Auto (Y axis auto scaling) | 2 |
| Jump | Intersect, Min, Max, X incpt, Y incpt | 5 |
| Range setting, Range menu | Range, Default, Power(3), Exp(4), Trig(5), Hyp(6) | 20 |
| Zoom | In, Out, Box, Factor | 4 |
| Graph type | Multiple, Fill | 2 |
| Numerical derivative | On/Off | 1 |
| Plot1 | Connect, Dot | 2 |
| Plot2 | Sequence, Simul | 2 |
| Plot type | Plot (Direct, Free), Line (Direct, Free), Clear | 5 |
| Trace | Trace, Change tracing graph | 2 |
| Save graph equation | 99 graph equations | 1 |





## Program mode

| Operation | Type | Total |
|---|---|---|
| Program type | Real, N-base, Matrix, Complex, Stat | 5 |
| Prog | Print, ", Input, Wait, Rem, End | 6 |
| Branch | Label, Goto, If, Gosub, Return | 5 |
| Inequality | <, <=, >=, =, ≠ | 6 |
| Graph | Graph, Auto, DotGraph, Range, Zoom, Plot, Line, Fill | 8 |
| Scrn | ClrT, ClrG, DispT, DispG | 4 |
| Stat | Stat x/xw/xy/xyw. Data, St | 6 |
| Stat graph | G(hist), G(B.L.), G(C.F.), G(N.D.), G(S.D.), G(B.C.) | 6 |
| Reg graph | G(line), G(exp), G(ln), G(log), G(pow), G(inv) | 6 |
| Save program | 99 programs | 1 |

## Option

| Operation | Type | Total |
|---|---|---|
| Screen and Memory | LCD contrast, Memory check | 2 |
| Data management | Copy, Move, Del | 3 |
| Data/Printer | Screenx1, Screenx2, List/Data | 3 |
| Data communications | Send, Send all, Backup | 3 |

## Total functions 437

The following tables list all of the EL-9200 calculator functions:

## Basic functions

| Operation | Type | Total |
|---|---|---|
| Function buffer | 32 functions, 14 numbers | 46 |
| Arithmetic calculations | +, −, ×, ÷, (−), Exp | 6 |
| Memories | A-Z, θ | 27 |
| Memory functions | STO, RCL | 2 |
| Last answer function | Ans | 1 |
| Play back function | Play back | 1 |
| Menu selection | Menu card | 1 |
| Editor function | CL, CA, DEL, BS, INS, ◀, ▶, ▲, ▼ | 9 |
| Equation editor | Fraction, Exponent, Root, Absolute, Integrate symbol, Parentheses | 6 |
| Angle mode setup | DEG, RAD, GRAD | 3 |
| Display format setup | Floating point, Fix, Sci, Eng/TAB 0-9 | 14 |
| Graphing mode setup | xy, rθ, xyt | 3 |
| Editor mode | Equation, One line | 2 |
| Display answer format | Decimal, Mixed, Improper | 3 |
| Complex answer format | x+yi, r∠θ | 2 |

## Calculation mode

| Operation | Type | Total |
|---|---|---|
| Trigonometric (in DEG, RAD, GRAD) | sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$ | 18 |
| Hyperbolic | sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$ | 6 |





| | | |
|---|---|---|
| Exponential and logarithmic | $e^x$, $10^x$, ln, log | 4 |
| Power | $a^b$, $x^2$, $x^{-1}$, $\sqrt[a]{}$, $\sqrt{}$ | 5 |
| Angle unit conversion | →dms, →deg | 2 |
| Coordinate conversion | →xy, →rθ | 2 |
| Factorial, permutation, combination | n!, nPr, nCr | 3 |
| Absolute, integer part, fractional part, integer | Abs, Ipart, Fpart, Int | 4 |
| Round | rndf | 1 |
| Numerical integration | ∫dx | 3 |
| Numerical differentiation | d/dx | 3 |
| Random number generation | random | 1 |
| Pi | π | 1 |
| 1-variable statistics | $\bar{x}$, sx, σx, Σx, $\Sigma x^2$, n, Xmax, Xmin | 8 |
| 2-variable statistics | $\bar{y}$, sy, σy, Σy, $\Sigma y^2$, Σxy, Ymax, Ymin | 8 |
| Regression analysis | a, b, r(linear) | 3 |
| Estimation | x', y' | 2 |
| Complex calculations | x+yi, r∠θ, (x+yi)•(r∠θ) | 3 |
| Complex functions | abs, $x^{-1}$, $x^2$ | 3 |
| Real part, imaginary part, angle, conjugate | Real, Image, Arg, Conj | 4 |
| N base | →bin, →oct, →hex, →dec | 4 |
| Conversion | bin↔oct↔dec↔hex | 12 |
| Logical operation | And, Or, Not, Neg, Xor, Xnor | 6 |
| Matrix memories | Mat A – Mat Z | 26 |
| Transposition, determinant, inverse, power, negation | Trns, Det, $x^{-1}$, $x^2$, (-) | 5 |

| | | |
|---|---|---|
| Row operations | Row swap, Row plus, Row mult, Row m.p. | 4 |
| Setting matrix size | Dim | 1 |

## Solver mode

| Operation | Type | Total |
|---|---|---|
| Solving method | Equation, newton, graphic | 0 |
| Save solve equation | 99 equations | 0 |

## Statistics mode

| Operation | Type | Total |
|---|---|---|
| 1-variable statistics | $\bar{x}$, sx, σx, $\Sigma x$, $\Sigma x^2$, n, Xmax, Xmin | — |
| 2-variable statistics | $\bar{y}$, sy, σy, $\Sigma y$, $\Sigma y^2$, $\Sigma xy$, Ymax, Ymin | — |
| Regression analysis | a, b, r(linear) | — |
| Estimation | x', y' | — |
| Data format | 1-variable with weight, 2-variable with weight | 4 |
| Select data card | First, Last, Any card | 3 |
| Data sorting | X-ascend/descend, Y-ascend/descend | 4 |
| Delete | 1 data, All data | 2 |
| Mask | On/Off | 1 |
| Save statistics data | A-Z (common use with matrices data) | 1 |
| Statistical graphs | Hist, B.L., C.E., N.D., S.D., B.C. | 6 |
| Regression curve | a+bX, $ae^{bX}$, a+bxlnX, a+bxlogX, $aX^b$, a+bx$X^{-1}$ | 6 |
| Statistics graph y-axis | Linear, % | 2 |





| | | |
|---|---|---|
| Process capability | Limit setting, On/Off, Cpk, Cp | 4 |
| Omega conversion | y, p | 2 |
| Auto scaling | x-y axis auto scaling | 1 |

## Graphics mode

| Operation | Type | Total |
|---|---|---|
| Rectangular, Polar, Parametric | xy, rθ, xyt | — |
| Draw type | Graph, Auto (Y axis auto scaling) | 2 |
| Jump | Intersect, Min, Max, X incpt, Y incpt | 5 |
| Range setting, Range menu | Range, Default, Power(3), Exp(4), Trig(5), Hyp(6) | 20 |
| Zoom | In, Out, Box, Factor | 4 |
| Graph type | Multiple, Fill | 2 |
| Numerical derivative | On/Off | 1 |
| Plot1 | Connect, Dot | 2 |
| Plot2 | Sequence, Simul | 2 |
| Plot type | Plot (Direct, Free), Line (Direct, Free), Clear | 5 |
| Trace | Trace, Change tracing graph | 2 |
| Save graph equation | 99 graph equations | 1 |

### Program mode

| Operation | Type | Total |
|---|---|---|
| Program type | Real, N-base, Matrix, Complex, Stat | 5 |
| Prog | Print, ", Input, Wait, Rem, End | 6 |
| Branch | Label, Goto, If, Gosub, Return | 5 |
| Inequality | <, <=, >=, =, ≠ | 6 |
| Graph | Graph, Auto, DotGraph, Range, Zoom, Plot, Line, Fill | 8 |
| Scrn | ClrT, ClrG, DispT, DispG | 4 |
| Stat | Stat x/xw/xy/xyw. Data, St | 6 |
| Stat graph | G(hist), G(B.L.), G(C.F.), G(N.D.), G(S.D.), G(B.C.) | 6 |
| Reg graph | G(line), G(exp), G(ln), G(log), G(pow), G(inv) | 6 |
| Save program | 99 programs | 1 |

### Option

| Operation | Type | Total |
|---|---|---|
| Screen and Memory | LCD contrast, Memory check | 2 |
| Data management | Copy, Move, Del | 3 |
| Data/Printer | Screenx1, Screenx2, List/Data | 0 |
| Data communications | Send, Send all, Backup | 0 |

### Total functions

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— MEMO —

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