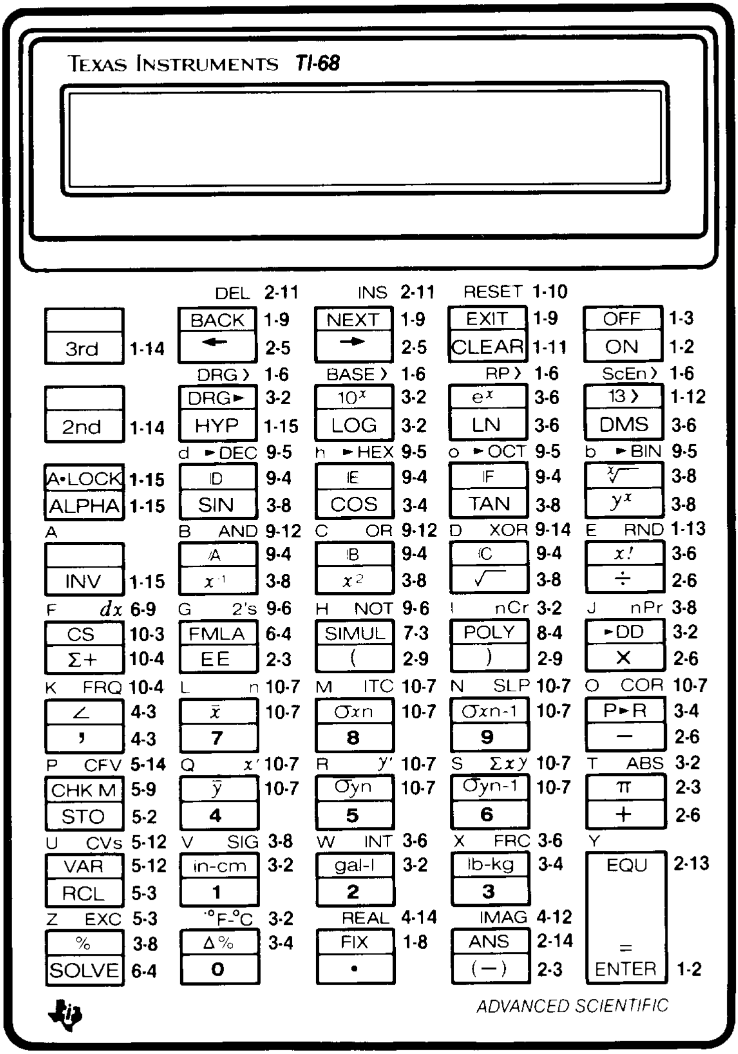
Texas Instruments

TI-68

Guidebook

Key Index

This indexed keyboard provides a quick page reference to the description of keys you may wish to read about.



TEXAS INSTRUMENTS

TI-68

GUIDEBOOK

Manual developed by: The staff of Texas Instruments Instructional Communications and the TI Corporate Design Center

With contributions by: Tammy L. Richards
Linda Ferrio
Patrick Milheron

Important

Texas Instruments makes no warranty, either express or implied, including but not limited to any implied warranties of merchantability and fitness for a particular purpose, regarding these book materials and makes such materials available solely on an "as-is" basis.

In no event shall Texas Instruments be liable to anyone for special, collateral, incidental, or consequential damages in connection with or arising out of the purchase or use of these materials and the sole and exclusive liability of Texas Instruments, regardless of the form of action, shall not exceed the purchase price of this product.

Table of Contents

Features of the TI-68 Scientific Calculator

The TI-68 scientific calculator is designed to perform many advanced functions and specialized operations that are useful in technical subjects. It can serve as a valuable tool both in school and in your career. This guidebook explains the many features of the calculator.

Alphanumeric Display

The display uses letters, numbers, and other symbols to show calculation entries including function names, operations, numeric values, and commands. Some activities help you along by placing prompts in the display. The display also has numerous indicators to show you the current settings and status.

Solutions to a System of Simultaneous Equations

The display prompts you for the coefficients and labels results, making it easy to enter and solve a system of simultaneous equations. The system can be up to fifth order, with either real or complex coefficients.

Extensive Complex Numbers

The TI-68 allows you to perform calculations with complex numbers in a natural, straightforward sequence. The functions that can handle complex numbers include arithmetic, reciprocal, powers and roots, logarithms, hyperbolic functions, and trigonometric functions. Real numbers and complex numbers can be used easily within the same calculation. While most other calculators stop with an error when a complex number should result, the TI-68 excels by providing a complex result.

Choice of Complex Number Forms

Because you may need a resulting complex number to be displayed in rectangular form or in polar form, the calculator has settings for both forms. An entry also can be in either form. You can even convert a complex number between the rectangular and polar forms.

Last Equation Replay

Allows recalling, checking, and editing of the last calculated equation. Allows you to replay the previous equation even if you have started a new equation.

Convenient Functions

In addition to the many standard scientific functions, the calculator has built-in combinations, permutations, hyperbolic functions, and metric conversions.

Formulas and Integration

The calculator has 440 bytes in 55 registers of memory space, enabling you to save simple or sophisticated calculation tasks. Entering your own formula is easy because it is much like entering an ordinary calculation. After entering a formula, you can evaluate or integrate it.

Alphanumeric Variable Names

You can use meaningful abbreviations for the names of variables and formulas. A name can be letters or a combination of letters and numbers.

Polynomial Roots

Given the coefficients of a second-, third-, or fourth-order polynomial, the calculator finds all real and complex roots of the polynomial.

Statistics with Linear Regression

You can enter a data set of either one- or two-variable observations. The results depend on whether the data set is one- or two-variable entries. For a two-variable data set, the calculator determines a regression line.

Choice of Number Bases

In addition to the decimal number system, the calculator enables you to perform integer operations with hexadecimal (base 16), octal (base 8), and binary (base 2) numbers. You also can convert between number bases.

Calculation Flexibility

By including three selectable angle units and conversions between them; along with settings for standard, scientific, engineering, and fixed-decimal notation; and also a set of symbols that give special meaning to a number, the calculator gives you control over the appearance of entries and results.

Constant Memory™ Feature

When you turn off the calculator, the Constant Memory™ feature retains the entries you have stored so that you can use them when you turn the calculator on again.

APD™ Automatic Power Down Feature

To extend the life of the calculator's battery, the APD™ Automatic Power Down feature automatically turns off the calculator after a few minutes if you do not press a key. You can resume operation by turning on the calculator.

Demonstration of the Outstanding Features

This session leads you through a demonstration of the outstanding features on the TI-68. Try this demonstration to see the calculator's capabilities, especially if you are not yet familiar with the calculator.

Calculator Settings

The calculator offers the versatility of several settings. To ensure that the demonstration proceeds as written, press [ON] [3rd] [RESET]. Then press [ALPHA] Y.

- ► If you need to retain memory contents, press [ALPHA] N and proceed with the demonstration.
- ► Otherwise, press [ALPHA] Y, [ALPHA] Y.

Last Equation Replay

Calculate $8^2 \times \log(25^{2.5} \div .03125)$.

Procedure	Press	Display
Begin the expression.	8 [x²] [×] [LOG] [(]	8²x log (_
Continue the entry.	25 [yˣ] 2.5 [÷]	g (25yˣ2.5÷_
Complete the entry.	.03125 [)]	2.5÷.03125)_
Evaluate the entry.	[ENTER]	320

Retrieve the last equation, modify it, and find the new result. Change .03125 to .3125.

Procedure	Press	Display
Retrieve the expression.	[2nd] [EQU]	8²x log (25y
Position the cursor at the 0.	[→] (repeatedly until at 0)	(25yˣ2.5÷.0
Delete the 0.	[3rd] [DEL]	(25yˣ2.5÷.3
Evaluate the entry.	[ENTER]	256

Complex Numbers

Find the product of two rectangular complex numbers.
(5.18,5.7)×(6.24,6) = ?

Procedure	Press	Display
Enter the expression.	[(] 5.18 [,] 5.7 [)] [×] [(] 6.24 [,] 6 [)]	7)×(6.24,6)_
Evaluate the entry.	[ENTER]	(-1.8768,66.648)

Find the sum of two polar complex numbers.
(13∠22.62) + (5∠53.13) = ? Set the calculator to show answers to four places after the decimal.

Procedure	Press	Display
Set fixed decimal.	[2nd] [FIX] 4	(-1.8768,66.6480)
Enter the expression.	[(] 13 [2nd] [∠] 22.62 [)] [+] [(] 5 [2nd] [∠] 53.13 [)]	)+(5∠53.13)_
Evaluate the entry.	[ENTER]	(15.0000,9.0000)
Set floating decimal.	[2nd] [FIX] [.]	(14.99999536,9.0

Combine complex and real numbers.
$(3,-4)^{-1} \times 10 + (6\angle -90) = ?$

Procedure	Press	Display
Enter the expression.	[(] 3 [,] [(-)] 4 [)] [x⁻¹] [×] 10 [+] [(] 6 [2nd] [∠] [(-)] 90 [)]	×10+(6∠-90)_
Evaluate the entry.	[ENTER]	(1.2,-4.4)

Polynomial Roots Find the roots of $25x^2 + 12x + 1.69 = 0$

Procedure	Press	Display
Begin second order polynomial roots.	[2nd] [POLY] 2	A2=?
Enter the coefficients.	25 [ENTER] 12 [ENTER] 1.69 [ENTER]	A1=? A0=? Rev i ew YN?
View the results.	[ALPHA] N [ENTER]	x1= (-0.24,0.1) x2= (-0.24,-0.1)

Solutions to a Real System of Simultaneous Equations

The calculator can rapidly determine the solutions to a system of simultaneous equations up to fifth-order. To keep this demonstration short, a second-order system of simultaneous equations is shown below. Find x_1 and x_2.

$6x_1 + 5x_2 = 1$
$2x_1 + 3x_2 = 4$

Procedure	Press	Display
Begin simultaneous equations.	[2nd] [SIMUL]	Equa 2–5?
Specify second order.	2	Comp l ex YN?
Specify real system.	[ALPHA] N	a11=?
Enter the coefficients row-by-row.	6 [ENTER] 5 [ENTER] 1 [ENTER] 2 [ENTER] 3 [ENTER] 4 [ENTER]	a12=? b1=? a21=? a22=? b2=? Rev i ew YN?
View the results.	[ALPHA] N [ENTER]	x1= -2.125 x2= 2.75

Solutions to a Complex System of Simultaneous Equations

A second order system of complex simultaneous equations is shown below. To keep results short for the display, set the calculator to show answers to three places after the decimal. Find x_1 and x_2.

$$(6.8,4.7)x_1+(9.3,8.7)x_2=(1.1,6.9)$$
$$(9.7,2.3)x_1+(8.7,5.5)x_2=(9.3,8.8)$$

Procedure	Press	Display
Set fixed decimal.	[2nd] [FIX] 3	_
Begin simultaneous equations.	[2nd] [SIMUL]	Equa 2–5?
Specify second order.	2	Comp l ex YN?
Specify complex.	[ALPHA] Y	a11=?
Enter the coefficients row-by-row.	[(] 6.8 [,] 4.7 [)] [ENTER]	 a12=?
	[(] 9.3 [,] 8.7 [)] [ENTER]	 b1=?
	[(] 1.1 [,] 6.9 [)] [ENTER]	 a21=?
	[(] 9.7 [,] 2.3 [)] [ENTER]	 a22=?
	[(] 8.7 [,] 5.5 [)] [ENTER]	 b2=?
	[(] 9.3 [,] 8.8 [)] [ENTER]	 Rev i ew YN?
View the results.	[ALPHA] N [ENTER] [→] [→]	x1=(1.923, 1.187) x2=(-0.915, -0.2 = (-0.915, -0.242)
Set floating decimal.	[2nd] [FIX] [·]	_

Formulas

Evaluate $Y = 10e^{-X/T}$ for several values of X when T = .5. Set the calculator for four decimal places. Let X be:

0, .2, .4, .6

Procedure	Press	Display
Set fixed decimal.	[2nd] [FIX] 4	_
Begin formula routine.	[2nd] [FMLA]	Name?
Enter the formula.	[ALPHA] Y [ENTER] 10 [×] [2nd] [eˣ] [(] [(-)] [ALPHA] X [÷] [ALPHA] T [)]	0× e^(-X÷T)_
Store the formula.	[ENTER]	Solve YN?
Evaluate the formula.	[ALPHA] Y	X=?
Enter X.	0 [ENTER]	T=?
Enter T.	.5 [ENTER]	Review YN?
Proceed with result.	[ALPHA] N	Y= 10.0000
Evaluate again.	[SOLVE]	X=0
Enter next X.	.2 [SOLVE]	Y= 6.7032
Evaluate again.	[SOLVE]	X=.2
Enter next X.	.4 [SOLVE]	Y= 4.4933
Evaluate again.	[SOLVE]	X=.4
Enter next X.	.6 [SOLVE]	Y= 3.0119
Set floating decimal.	[2nd] [FIX] [.]	_

Integration

Integrate the formula (entered on the previous page) with respect to X. Use a lower limit of 0, an upper limit of .6, and three intervals.

Procedure	Press	Display
Begin formula routine.	[2nd] [FMLA]	Name?
Specify the formula and begin evaluation.	[ALPHA] Y [ENTER] [ENTER] [ALPHA] Y	X=_.6
Declare X as the independent variable.	[CLEAR] [3rd] [dx] [ENTER]	low=?
Enter lower limit.	0 [ENTER]	up=?
Enter upper limit.	.6 [ENTER]	intrv=?
Specify intervals.	3 [ENTER]	T=_.5
Accept T.	[ENTER]	ReviewYN?
Proceed with result.	[ALPHA] N	Y=3.494059851

When You Finish

You can turn the calculator off by pressing [2nd] [OFF].

The TI-68 Guidebook

This guidebook is written to meet your needs, provided you have experience with scientific calculators and already know some advanced math.

Choosing the TI-68

The wide variety of available calculators enables you to choose one that fits your specific calculation needs. Because you have chosen the TI-68, you probably already know some general concepts of scientific calculators.

Your Knowledge of Functions

This guidebook does not attempt to explain widely taught functions, but it does show each function in one or more examples. For mathematical descriptions of the functions, consult other sources such as textbooks, classroom instruction, or a library.

Key Symbol Conventions

A key symbol can appear in:

- ► A box, meaning that the key is a primary function such as `SIN`.
- ► Square brackets, meaning that the key is a second or third function such as `2nd` [D] or `3rd` [►DEC].
- ► Angle brackets, meaning that the key is a nonalphabetic alpha function such as `ALPHA` ⟨d⟩.

Pages 1-14 and 9-2 describe these types of alternate functions.

Chapter 1: Using the Fundamental Features

This chapter introduces the fundamental features that you should know when you are using your TI-68 scientific calculator.

Chapter Contents

Turning the Calculator On and Off

The [ON] and [2nd] [OFF] keys turn the calculator on and off. The Constant Memory™ feature retains stored entries even when you turn off the calculator. If you forget to turn the calculator off, the APD™ Automatic Power Down feature turns it off for you.

Effects of Turning the Calculator On

When the calculator is off and you press [ON], the display shows a variety of alternatives, depending on what occurred when the calculator was turned off.

- If you pressed [2nd] [OFF] to turn off the calculator, turning it on places a cursor in the empty display, and all settings remain in effect. The calculator is ready for your entries.
- If the batteries were replaced, turning the calculator on shows the message **Mem cleared**, and all settings are reset to their defaults.
- If APD™ turned off the calculator, turning the calculator on resumes any entry or sequence that was in progress.

Some indicators also appear at the top of the display area and are described later in this chapter.

When the Calculator Is Turned On

You can use the calculator more effectively if you know some fundamental concepts concerning its design.

- The calculator's display shows the numbers being entered and the operations to be performed on the numbers. You can review all of a problem in the entry line before computing the result. To obtain the result, press [ENTER].
- The calculator has several settings that you can adjust to select the way results appear. These settings are discussed later in this chapter.
- The calculator does not confine different kinds of numbers (such as numbers in different bases) to specific "modes." By including certain symbols with a number, you can use it along with any other kind of number in any appropriate calculation.

Effects of Turning the Calculator Off

Depending on the activities you may have been performing prior to turning off the calculator, it retains certain items and clears others. Settings, stored entries, and the last equation and its result (if these are present) are always retained.

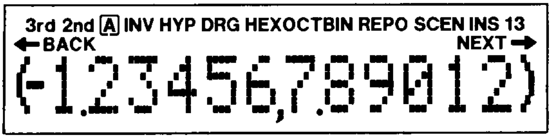
Activity	Effect of Pressing [2nd] [OFF]
Entering a problem	The current entry is cleared.
Viewing a result	The result is saved as the last answer, and the display is cleared.
Advancing through sequenced entries or results.	The sequence is exited, and the display is cleared.
Waiting for a computation to reach completion.	Any turn-off attempt is ignored.

APD™ Feature

To conserve battery power, the APD™ Automatic Power Down feature automatically turns off the calculator if you do not press any key for a few minutes. In contrast to pressing [2nd] [OFF], any entry or activity that was in progress when APD™ turned the calculator off is resumed when you press [ON].

The Display Area

The display shows 12 characters of the entry line. Each character is a 5 × 7 dot matrix. There are also indicators for many of the settings and alternate functions, and for when information is beyond the display. Dedicated punctuation can combine with the dot matrix characters to enhance results.



Display Indicators

Indicator	Meaning
3rd	The calculator will access the third function of the next key pressed.
2nd	The calculator will access the second function of the next key pressed.
A, [A]	When A appears, the calculator will type the alpha symbol of only the next key pressed; and when [A] appears, alpha lock is in effect and the keys will type alpha symbols until the alpha lock is turned off.
INV	The calculator will access the inverse function of the next key pressed.
HYP	The calculator will access the hyperbolic function of the next key pressed.
D, R, G	When D appears, angle units are set to degrees; when R appears, angle units are set to radians; and when G appears, angle units are set to grads.
HEX OCT BIN	When HEX appears, the default number base is hexadecimal; when OCT appears, the default number base is octal; when BIN appears, the default number base is binary; and when none of these indicators appears, the default number base is decimal.
RE, PO	When RE appears, a complex result is shown as rectangular coordinates; and when PO appears, a complex result is shown as polar coordinates.

Display Indicators (Continued)

Indicator	Meaning
SC, EN	When SC appears, scientific notation is selected; when EN appears, engineering notation is selected; and when neither of these indicators appears, standard notation is selected.
INS	Numbers and functions will be inserted at the current cursor position.
13	When 13 appears, 13-digit precision is selected; and when this does not appear, 10-digit precision is selected.
←, →	When ← appears, information is past the left end of the display; and when → appears, information is past the right end of the display. You can scroll to see the rest of the line by pressing [←] or [→]. These keys repeat when held down.
BACK NEXT	When BACK appears, the display is showing the last entry or result in a sequence; and when NEXT appears, more of the sequence is after the current number. You can advance either direction through a sequence by pressing [2nd] [NEXT] or [2nd] [BACK].

Dedicated Punctuation in Results

Entries can occupy only the dot matrix characters. However, a result often appears using some dedicated punctuation along with the dot matrix characters. This accompanying punctuation enables more of a result to appear than would otherwise be possible in 12 characters. The dedicated punctuation is:

Leftmost parenthesis "("	This begins a complex number.
Leftmost negative sign "-"	This begins a negative number.
Embedded decimal "."	This is a decimal point.
Embedded comma ","	This separates parts of a rectangular complex number.
Rightmost parenthesis ")"	This ends a complex number.

Calculator Settings

Depending on how you intend to use the calculator, you should adjust the settings for various aspects of its operation. One of the settings is fixed decimal, described later in this chapter. The rest of the settings are described on this page.

Settings to Adjust

Five of the calculator settings operate in a "rotary" fashion. The keys for these settings are located on the second row of the keyboard and include > at the end of the key name.

Setting Name	Choices	To Advance	Meanings of Indicators	
Angle Units	Degrees → Radians → Grads → Degrees	[3rd] [DRG>]	D R G	Degrees Radians Grads
Default Number Base	Decimal → Hexadecimal → Octal → Binary → Decimal	[3rd] [BASE>]	None HEX OCT BIN	Decimal Hexadecimal Octal Binary
Complex Number Form	Rectangular → Polar → Rectangular	[3rd] [RP>]	RE PO	Rectangular Polar
Digits of Precision	10 digits → 13 digits → 10 digits	[2nd] [13>]	None 13	10 digits 13 digits
Notation	Standard → Scientific → Engineering → Standard	[3rd] [ScEn>]	None SC EN	Standard Scientific Engineering

More on the Settings

For some of the settings, the following concepts are important.

Angle Units

The angle units determine whether the calculator interprets angles for trigonometric functions as degrees, radians, or grads. This setting also determines how you should interpret angles that result from inverse trigonometric functions.

These units are defined by the angle of a full circle: 360 degrees = 2π radians = 400 grads.

It is possible to show a result whose expected angle units do not match the angle units indicators. By selecting the appropriate angle units manually, you can avoid an angle units discrepancy.

Complex Number Form

The complex number form determines how a result is shown. It does not affect the way you enter a complex number.

The rectangular form shows the number as real and imaginary parts, and the polar form shows the number as the magnitude and angle in the currently selected angle units.

Notation

The notation determines how a result is shown. It does not affect the way you enter a number.

Both scientific and engineering notation state a number as a value multiplied by 10 raised to a power. However, the exponent is adjusted to a multiple of three for engineering notation.

Fixed Decimal Format

The fixed decimal format is a way of writing a number with a predetermined number of digits after the decimal. By using the fixed decimal format, you can set all results to appear with a uniform degree of accuracy, without affecting the internal value maintained by the calculator.

Selecting Fixed Decimal Format

To set the number of decimal places, press [2nd] [FIX] followed by the appropriate digit key ([0] through [9]).

To remove the fixed decimal setting and return to floating decimal, press [2nd] [FIX] [.].

When you have pressed [2nd] [FIX] but have not completed the selection, the current entry disappears until you press a digit key, [.], or [CLEAR]. Then the previous display is restored.

Effects of Fixed Decimal Format

When a fixed decimal format is selected, standard results appear with a specific number of places past the decimal.

- If a result has more than the selected number of decimal places, the result is shown rounded.
- If a result has fewer than the selected number of decimal places, trailing zeros appear with the number.
- If a result is in scientific or engineering notation, deg/min/sec format, or a nondecimal number base, the fixed decimal setting is ignored.

Performing calculations with a fixed decimal format selected does not affect the internal value.

Example

Show 1.357 in fix 2, in fix 6, and in floating decimal.

Procedure	Press	Display
Select floating decimal and clear the entry line.	[2nd] [FIX] [.] [CLEAR]	_
Enter the number.	1.357 [ENTER]	1.357
Select fix 2.	[2nd] [FIX] 2	1.36
Select fix 6.	[2nd] [FIX] 6	1.357000
Select floating decimal.	[2nd] [FIX] [.]	1.357

Sequenced Activities

Sequenced activities are those in which the calculator leads you through a sequence. In a sequenced activity, you may be responding to the calculator's questions, providing numbers for prompted coefficients, or viewing answers in a solution set.

Features That Include a Sequenced Activity

You encounter a sequenced activity when:

- You use keys that clear certain areas of the calculator for which the calculator requires confirmation.

3rd [RESET]	3rd [CFV]
2nd [CS]	3rd [CVs]

- You use a feature that involves a group of entries or results.

2nd [SIMUL]	2nd [VAR]
2nd [POLY]	2nd [FMLA]
3rd [Σxy]	SOLVE

Pressing 2nd [EXIT] leaves this type of sequence.

Advancing Through Grouped Entries

You can advance either direction when reviewing grouped entries by pressing 2nd [NEXT] or 2nd [BACK].

In most of the actvities, you can substitute ENTER for 2nd [NEXT].

Responding to a Yes/No Prompt

Ordinarily you must press ALPHA before typing Y or N. However, when responding to one of the calculator's yes/no prompts, you can omit pressing ALPHA.

- To respond yes, press ENTER, which is the key shared by Y.
- To respond no, press 9, which is the key shared by N.

Viewing Grouped Results

When the calculator is presenting a group of results, the NEXT indicator appears with each result until you advance to the last one. Then the BACK indicator appears. To advance through grouped results, press ENTER, 2nd [NEXT], or 2nd [BACK].

Advancing past the last result of the group returns you to the first result.

Resetting the Calculator

Using reset can select all default settings and clear everything. Because there are other ways to clear that affect only specific items, you should reserve the reset function for appropriate situations. You might choose to reset when you first purchase the calculator, or when required to in a classroom situation.

Alternatives to Resetting

Before you use reset, consider the other methods for clearing described on the next page. For example you can clear an individual formula without resetting.

Reset Procedure

When you press [3rd] [RESET], the calculator exits from any sequenced entries or results and clears any entry in progress. Then:

1. The display shows **Defaults YN?**

   - To leave the settings unaffected, respond N.

   - To reset the six settings, respond Y.

     Angle unit resets to degrees.
     Default number base resets to decimal.
     Complex number form resets to rectangular.
     Digits of precision resets to 10 digits.
     Notation resets to standard.
     Fixed decimal format resets to floating.

2. The display shows **Clr Mem YN?**

   - To leave memory intact and end the reset sequence, respond N.

   - To choose to clear the memory, respond Y.

3. The display shows **Confirm YN?** This prompt gives you the chance to reconsider because memory may contain formulas or other data that would be difficult to restore.

   - To leave memory intact and end the reset sequence, respond N.

   - To clear all variables, formulas, and the statistics data set, respond Y. The message **Cleared** is shown.

Clearing

You can clear individual items or certain groups of items with the key sequences listed below.

Methods of Clearing

The following table helps you use the clearing features.

Item to Clear	Method
Entry line	Press [CLEAR].
An incomplete fix or Rcl, but not other items of the current entry	Press [CLEAR].
A value asked for in a prompt, but not the prompt	Press [CLEAR].
Sequence of entries	Press [2nd] [EXIT].
Sequence of results	Press any key other than [←], [→], [ENTER], [2nd] [NEXT], [2nd] [BACK], or [STO].
Statistics data set	Press [2nd] [CS] Y.
An individual formula or variable	Use [2nd] [VAR] or [2nd] [FMLA] to specify the name and press [3rd] [CFV] Y.
All variables	Press [3rd] [CVs] Y.

Computational Accuracy

The calculator achieves its accuracy by having more digits internally than are shown in the display. These extra internal digits guard against visible inaccuracies by keeping roundoff error past the 10th digit, and are called guard digits. You can select two ways for the guard digits to be used.

Digits of Precision Setting

The two choices for the digits of precision are:

- 10-digit—Results appear with up to 10 digits. For calculations executed together in the same entry, 10-digit precision keeps the guard digits until the answer appears, showing the same result as 13-digit precision. However, slight differences may become visible in successive calculations. The advantage of 10-digit precision is that most numbers are more compact in a subsequent calculation.

- 13-digit—Results appear with up to 10 digits, and internally the guard digits remain to preserve accuracy. A number, when used in a subsequent calculation, occupies up to 13 digits in the entry line for the 13-digit setting, compared to a maximum of 10 digits in the 10-digit setting.

To switch between 10-digit and 13-digit precision, press [2nd] [13>].

Rounding a Result

If a calculation produces a result that is more than 10 digits, the calculator uses the guard digits to determine how to display the result.

- If the first digit past the visible display is 5 or greater, the calculator automatically rounds the result to the next larger value in the last displayed digit.

- If the first digit past the visible display is 4 or less, the guard digits do not affect the displayed result.

If 10-digit precision is selected, the internal value is replaced with the 10-digit rounded value after all calculations in the entry line are completed. If 13-digit precision is selected, the unrounded result remains for subsequent calculations.

The Round Function

The round function (rnd) rounds the internal value to 10 digits. If you use rnd with a complex number, both parts are rounded. The syntax for rounding a number is:

rnd *number*

1. Begin with the rnd function ([3rd] [RND]).
2. Follow it with the number or expression that is being rounded.

To execute an entry, press [ENTER].

Comparison of Internal and Displayed Results

Consider the problem $1.9081 \times 2.4207 \times 2.165$. The true result is 10.00000005555.

The calculator shows 10.00000006 when set to floating decimal notation and has the following internal results.

Internal result for 13-digit setting	10.00000005555
Internal result for 10-digit setting	10.00000006000
Internal result of rnd(1.9081 × 2.4207 × 2.165)	10.00000006000

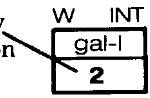
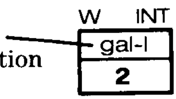
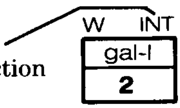
If the calculation is entered with rounding, the internal result is the same for either 10-digit or 13-digit precision.

Understanding the Keyboard

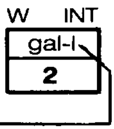
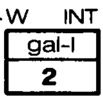
To make the most of the TI-68 keyboard, almost every key has more than one purpose. The primary function of a key is marked on the lower half of the key. Other purposes of the key are marked higher on the key, marked above the key. Some functions also have an inverse function.

Using Alternate Functions

This table assists you in using alternate functions.

Interpreting the Keyboard Markings	Access Method	Indicator Activity
A function is marked on the lower portion of its key. Primary Function 	When none of the alternate function indicators (2nd, 3rd, INV, HYP, or A is visible, press the key shared by the desired function.	Because you press a single key to access a primary function, no indicator for a partial key sequence is needed.
A function is marked on the upper portion of its key. 2nd Function 	1. Press [2nd]. 2. Press the key shared by the desired function.	After you press [2nd] but before you press another key, 2nd appears. It disappears when you press another key (except [INV]).
A function is marked above the top right corner of its key. 3rd Function 	1. Press [3rd]. 2. Press the key shared by the desired function.	After you press [3rd] but before you press another key, 3rd appears. It disappears when you press another key (except [INV]).

Using Alternate Functions (Continued)

Interpreting the Keyboard Markings	Access Method	Indicator Activity
The function is needed to do the opposite of a function that is marked.  Inverse Function Implied (Here, an opposite conversion is needed.)	1. Press [INV]. 2. Press as needed: [2nd], [3rd], [HYP], or no alternate function. 3. Press the key shared by the desired function.	After you press [INV] but before you press another key, INV appears. It disappears when you press another key (except [2nd], [3rd], or [HYP]).
The function is a hyperbolic or an inverse hyperbolic. Only three keys are appropriate as hyperbolic functions.	1. Press as needed: [HYP], [HYP] [INV], or [INV] [HYP]. 2. Press one of the three applicable keys: [SIN], [COS], or [TAN].	After you press [HYP] but before you press another key, HYP appears. It disappears when you press another key (except [INV], [2nd], or [3rd]).
A function is marked above the top left corner of its key. Alpha Function 	1. Press [ALPHA]. 2. Press the key shared by the desired function. Or: 1. Press [2nd] [A•LOCK]. 2. Press keys for the desired alpha functions. 3. Cancel the alpha lock by pressing [2nd] [A•LOCK] or [ALPHA].	After you press [ALPHA] but before you press another key, A appears. It disappears when you press another key (except [2nd] or [3rd]). When the alpha lock is in effect, [A] appears until you cancel the alpha lock.

Replacing or Cancelling an Alternate Function

When you have begun a second or third function, you can replace [2nd] with [3rd] or [3rd] with [2nd].

When you have begun a hyperbolic or alpha function, you can replace [HYP] with [ALPHA] or [ALPHA] with [HYP].

If you accidentally press an undesired alternate function key such as [2nd], you can easily cancel it. To cancel, press the key again.

If you select an alternate function and press a key for which that alternate function does not apply, the key accesses the primary function. For instance, [HYP] [LOG] is the same as [LOG].

Combined Alternate Functions

INV can be combined with 2nd, 3rd, or HYP to access the inverses of certain alternate functions. You can press [INV] before or after [2nd], [3rd], or [HYP]. Either order selects the same combined alternate function.

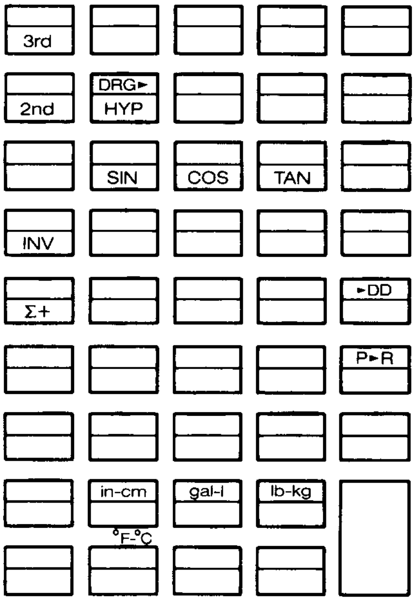
If you select a combined alternate function and press a key for which neither alternate function applies, the key accesses the primary function. For instance, [INV] [HYP] [÷] is the same as [÷].

If you select a combined alternate function and press a key for which only one of the alternate functions apply, the key ignores the alternate function that does not apply and accesses the alternate function that does apply. For instance, [INV] [2nd] [π] is the same as [2nd] [π].

If you select alpha combined with 2nd or 3rd, and press a key for which both of the alternate functions apply, the key ignores the alpha selection and accesses the 2nd or 3rd function. For instance, [ALPHA] [2nd] [x!] is the same as [2nd] [x!].

Inverse Function Keyboard

The [INV] key works with certain primary, second, third, and hyperbolic functions to access an inverse function. A diagram of the keys that work with [INV] appears below.



Representation of a Function

Many of the functions are abbreviated differently on the keyboard than they are in the display.

- As a key label, a function needs to appear in its most eye-catching form, enabling you to find a function quickly when scanning the keyboard.
- As a displayed item, a function needs to be distinguishable from a variable, enabling you to interpret the display with greater clarity.

The difference is often the capitalization of the abbreviation.

Chapter 2: Entering Numbers and Calculations

This chapter presents the features that you use to enter numbers and to perform calculations.

Chapter Contents

Number Entry Options

When you enter a number, you can include accompanying symbols along with the digits. The digits and symbols together form a number for the calculator to interpret.

Before You Begin a New Calculation

The calculator is ready for you to enter a new problem after you press [ENTER] to execute a calculation. You do not need to clear the display unless you wish to discard an entry that you have begun but not executed. To clear the display line, press [CLEAR]. This key has no effect on stored values, formulas, or the statistics data set.

Digits of an Entry

The number base of an entry determines the digits that are valid for that entry.

- A decimal (base ten) entry can consist of the digits 0 through 9.
- Entries for the other number bases (hexadecimal, octal, and binary) have different sets of digits, which are presented in Chapter 9.

Symbols That Can Accompany Digits in a Number

Along with the digits of a number, you can include symbols to modify the meaning of the number. These symbols remain part of the number even if you store it in memory. The settings the calculator has for the appearance of results do not affect the types of numbers you can enter.

- To make the number negative, place a minus symbol ahead of the number using the [(-)] key (which is different from the subtraction key [-]). Negation is explained in detail on the next page.
- To enter the number as degrees, minutes, and seconds, punctuate the number using the [DMS] key. This feature is presented in Chapter 3.
- To pair two numbers as the parts of a complex number, use parentheses and the comma or angle separator. This feature is presented in Chapter 4.
- To designate that a number is in a specific number base, include the symbol for decimal (d), hexadecimal (h), octal (o), or binary (b) just after the number. This feature is presented in Chapter 9.

The Negation Function

The effect of the negation symbol depends on how it is used in an entry. You can place a "–" ahead of:

- A number or exponent of scientific notation. The number or exponent becomes negative.
- A variable, a recalled number, a statistics result, or pi. The value becomes negative.
- A function that belongs ahead of a number or an open parenthesis. The negation function will be performed when the entry is executed.

Entering a Number in Scientific Notation

To enter a number in scientific notation:

1. If the number is negative, press [(-)].
2. Type the part of the number that belongs before the exponent (often called the mantissa), up to 13 digits. Include the decimal where appropriate.
3. Press [EE]. An E appears in the display. This E is smaller than the alpha E or the hex digit E.
4. If the exponent is negative, press [(-)].
5. Type one or two digits for the exponent.

Entering a number in scientific notation does not cause the results to be shown in scientific notation. The notation used for results depends on the setting that you adjust with [3rd] [ScEn>] and the ability of the result to fit in 10 digits.

The Number Pi

Instead of entering the digits of pi separately, you can use the [2nd] [π] key sequence to place the π symbol in the display. Internally, the 13-digit value for π (3.141592653590) is used.

Variables

You can use a variable in place of a number. This feature is described in Chapter 5.

Entry Terminology and Capacities

The entry line is longer than the visible display. You can consider the display as a window showing 12 characters of the entry. An entry that has more than 12 characters goes beyond the display. The calculator has features to help you recognize when an entry is nearing the capacity of the entry line.

Entry Length

A decimal number can have up to 13 digits and two exponent digits (13 digits and two exponent digits for each part of a complex number). A number in DMS format can have up to nine digits. A hexadecimal, octal, or binary number can have up to 10 digits. Along with the numbers, an entry consists of functions and operations of the expression.

Each digit or symbol (such as a comma or decimal point) in a number is considered to be an item in the entry. Each letter of a variable name is also one item. However, a function or operation is just one item even though it appears to have more than one character. For example, **log** is one item even though it has three characters.

You can think of the terms "equation" and "formula" as specific cases of the more general term, expression.

- **Equation**— an expression that you enter for temporary use. An equation can have up to 80 items.
- **Formula**— an expression that you save for later use. You name each formula before you enter it. A formula can have up to 79 items.

When you are approaching the length limit, the cursor changes from an underline to a box after the 70th item. When your expression reaches the length limit, any key that would place another item in the display is ignored.

Note that your entry can approach the length limit even though you may not be at the end of the entry line. You can also reach the length limit while:

- Inserting items within an expression.
- Recalling a number within an expression, which inserts the individual digits and symbols of the number.

Reviewing a Long Entry

You can look for arrow indicators near the upper corners of the display to determine whether an entry goes past the display. If ← appears, more of the entry is to the left of the display. If → appears, more of the entry is to the right of the display.

To review a long entry before executing it, scroll the entry by pressing the [←] and [→] keys. [←] shifts the cursor to the left and [→] shifts the cursor to the right. These keys automatically repeat when held down.

Equation Operating System

The Equation Operating System enables you to enter numbers along with operations into the calculator in a simple, straightforward sequence. This system incorporates the standard priorities of mathematical operations and also has parentheses for grouping an expression.

Algebraic Hierarchy

Without a fixed set of algebraic rules, an expression such as $16 - 8 \div 2 + 6$ might have several possible answers, depending on the order in which the operations are completed. However, the established hierarchy of operations calls for completing the division first ($8 \div 2$) and then completing the subtraction and addition. Therefore, $16 - 8 \div 2 + 6 = 18$.

Purpose of the Equation Operating System

The calculator supports the rules of the algebraic hierarchy with its Equation Operating System. The EOS decides whether an operation is to be completed or temporarily delayed based on the priorities shown in the following table.

Priority	Operations
1 (highest)	Functions that are entered after their argument: square, factorial, reciprocal, conversions, percent
2	Functions that are entered before their argument: square root, negation of an expression, round, absolute value, signum, integer portion, fractional portion, real part, imaginary part, logarithms, hyperbolic functions, trigonometric functions, not, two's complement, y′, x′
3	delta percent, combinations, permutations
4	universal power, universal root
5	multiplication, division
6	addition, subtraction
7	logical and
8 (lowest)	logical or, logical xor

Purpose of the Equation Operating System (Continued)

When the calculator is executing a calculation, it starts at the left and progresses to the right. As the calculator proceeds with an expression, it must decide whether to delay each operation or to perform it.

- If the current operation is in the top priority of the algebraic hierarchy, it is performed.
- If the current operation is below the top priority, it is delayed. The operation and its associated value (if appropriate) are placed in temporary storage areas.
- If the current operation is encountered when the calculator is already delaying operations, it performs the delayed operations that have equal or higher priority than the current operation.

When the calculator reaches the end of the expression, it performs any remaining delayed operations to arrive at the answer.

When a priority 2 operation is delayed, it has no associated pending value. When a lower priority operation is delayed, it has an associated pending value. The maximum number of pending operations is always 24. The maximum number of pending values is ordinarily eight (real or complex). During the following activities, the maximum is reduced to six real or three complex.

- Finding polynomial roots
- Solving a system of simultaneous equations

Although the calculator internally may manage several pending operations, arrive at many intermediate values, and ultimately combine the whole expression into one answer, it all happens in the brief time it takes the answer to appear.

Example

Calculate $4 \div 5^2 \times 7 + 3 \times .5^{\cos 60°}$.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select degrees.	If D is not indicated, press [3rd] [DRG>] until it is.	_
Begin the expression.	4 [÷] 5 [x²] [×] 7 [+] 3 [×]	4÷5²x7+3x_
Complete the entry.	.5 [yˣ] [COS] 60	.5yˣ cos 60_
Evaluate the expression.	[ENTER]	3.241320344

During execution of this example, the calculator:

1. Delays division while it squares the five. — 4÷25
2. Completes division when it encounters multiplication. — 0.16x
3. Completes multiplication when it encounters addition. — 1.12+
4. Delays addition when it encounters multiplication. — 1.12+3x
5. Also delays multiplication when it encounters y^x. — 1.12+3x.5 y^x
6. Also delays y^x while it takes the cosine of 60. — 1.12+3x.5y^x.5
7. Completes y^x, then multiplication, and finally addition. — 1.12+3x0.7071067812 / 1.12+2.121320344 / 3.241320344

Parentheses

Parentheses enable you to control how the calculator handles an expression by giving priority to specific sections of the expression. When the calculator encounters "(" during execution, it reprioritizes the operations within the parenthetical expression to complete them before other parts of the entry, creating a pending open parenthesis. When the calculator executes ")", it completes back to the most recent open parenthesis.

The calculator requires each close parenthesis to match with an open parenthesis. If the number of consecutive open parentheses exceeds 16, the calculator stops with an error condition.

Using parentheses for implied multiplication such as 7(3 + 5) is invalid. The calculator requires the times symbol whenever multiplication is intended.

You can omit any close parentheses at the end of a calculation. All open parentheses are automatically closed when you press [ENTER].

Example

Calculate 7 × (3 + 5) with and without the last parenthesis.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Enter the expression with both parentheses.	7 [×] [(] 3 [+] 5 [)]	7×(3+5)_
Evaluate the expression.	[ENTER]	56
Enter the shortened expression.	7 [×] [(] 3 [+] 5	7×(3+5_
Evaluate the expression.	[ENTER]	56

If this calculation were performed without parentheses, the result would be 26 because 7 × 3 would be evaluated first.

Revising an Expression

By recognizing when an expression contains an error, you can correct it before proceeding with the calculation. Instead of handling a mistake by clearing the entire entry and starting over, you can correct the mistake by selectively deleting and retyping or inserting only parts of the entry.

Possible Entry Errors

A number that contains any of the following mistakes causes the calculator to stop with an error condition at that point in an expression.

- An extra decimal point
- Misplaced negation
- Invalid exponent of scientific notation: a character other than negation or 0 through 9 is present
- Inappropriate characters for a decimal number: a DMS number with scientific notation, more than 13 digits in a number, or an extra comma or angle symbol in a complex number pair
- Inappropriate characters for a nondecimal number: scientific notation, a decimal point, a DMS number, a complex number, or more than 10 digits in a number

Syntax mistakes also cause an error.

- Mismatched close parenthesis
- Adjacent symbols that do not belong together
- Functions that belong before their argument but occur after their argument
- Functions that belong after their argument but occur before their argument
- Using a variable that is not defined

Ways to Make a Correction

If you notice a mistake in your current entry before you press [ENTER], you can position the cursor at the mistake and:

- Type over incorrect symbols.
- Delete extra symbols with [3rd] [DEL].
- Insert missing symbols with [3rd] [INS].

If you realize a mistake is present after you press [ENTER], you can use the last equation feature (discussed in the next section) to retrieve the expression, and then revise it.

Inserting Numbers and Functions

To insert at a desired position in an entry:

1. Use [←] and [→] to position the cursor at the character that belongs just after the inserted material.

2. Press [3rd] [INS]. The INS indicator appears.

3. Type the inserted material.

4. Decide how to end the insert.

   - To insert the material you just typed, move the cursor with [←] or [→].

   - To insert the material you just typed and delete the next character, press [3rd] [DEL].

   - To insert the material you just typed and execute the expression, press [ENTER].

Deleting Numbers and Functions

To delete an item in the entry:

1. Use [←] and [→] to position the cursor at the first character that is to be deleted.

2. Press [3rd] [DEL]. Numbers and variables are deleted one character at a time. All the characters of a function that is represented by a group of characters (such as **log**) are deleted together.

Example

Calculate 10.1 – 4.2 + 1.3, but omit the second number and enter the third number incorrectly. Then correct the entry.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Enter the expression, but omit the second term and end with 22.3.	10.1 [+] 22.3	10.1+22.3_
Position the cursor at the mistake.	[←] [←] [←] [←] [←]	10.1+22.3
Insert the missing term.	[3rd] [INS] [–] 4.2	10.1–4.2+22.
Delete the extra digit.	[→] [3rd] [DEL]	10.1–4.2+2.3
Correct the digit.	1	10.1–4.2+1_3
Evaluate the expression.	[ENTER]	7.2

Using the Last Equation Feature

If you need to view or modify the most recently entered equation, you can use the last equation feature to retrieve the equation as the current entry.

Retrieving the Last Equation

To retrieve the last equation, press [2nd] [EQU]. Retrieving the last equation replaces the current entry. The last equation is updated each time you press [ENTER] to execute an equation.

The last equation feature is especially helpful after an error condition. Execution stops when an error condition occurs. For most types of errors, the calculator locates the error for you.

- To see the last equation with the cursor at the error, respond to an error condition by pressing [2nd] [EQU]. If the cursor is at the end of the expression, it usually means an overflow occurred.
- To clear the error without viewing the point at which execution stopped, respond to an error by pressing [CLEAR], [2nd] [EXIT], or [2nd] [OFF]. Clearing with these key sequences and then retrieving the last equation places the cursor at the start of the equation.

Other than the four responses listed above, the calculator ignores any keys you press during an error condition.

Example

While intending to enter 5 ÷ -8 + 4, mistakenly press [−] instead of [(-)]. Correct the mistake and obtain the result.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Enter the problem incorrectly.	5 [÷] [−] 8 [+] 4 [ENTER]	Error
Retrieve the entry.	[2nd] [EQU]	5÷-8+4
Revise the entry.	[(-)]	5÷-8+4
Evaluate the expression.	[ENTER]	3.375

Using the Last Answer Feature

If you need to view or reuse the most recently obtained answer, you can use the last answer feature to retrieve the answer into the current entry.

Retrieving the Last Answer

To retrieve the last answer, press [2nd] [ANS]. If your current equation calls for the last answer repeatedly, you can retrieve the last answer more than once. The last answer is updated each time you press [ENTER] to execute an equation.

An error condition sets the last answer to zero.

Regardless of the format used to display the answer of the last calculation, retrieving the last answer places all the internal digits of the number into the entry line.

When to Use the Last Answer

You should retrieve the last answer when the next expression uses the number and the number occurs after the beginning of the expression. When you begin an entry with an operation other than those in priority 2, the last answer is automatically retrieved ahead of the operation.

Example

Calculate the square of 6. Add it to the square of 8. Take the square root of the result.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Calculate first result.	6 [x^2] [ENTER]	36
Calculate the next result.	[+] 8 [x^2] [ENTER]	100
Calculate the final result.	[√] [2nd] [ANS] [ENTER]	10

Chapter 3: Scientific Functions

This chapter presents the various scientific functions of the calculator. To match the way that you ordinarily write certain scientific functions before a number ($\sqrt{5}$, log5), you enter such functions before the number in a calculation. To match functions that you write after a number (5^2), you enter such functions after the number in a calculation.

Chapter Contents

Alphabetical Table of Scientific Functions

To see an example of a desired scientific function, find the function in the following table alphabetized by name. An answer that extends past the display is marked [→]*, meaning that to view the rest of it, you should press and hold [→]. Unless otherwise indicated, the angle units setting is degrees and the number base setting is decimal.

Function	Comments	Example
Absolute value		$\|-7.2\|$
Arccosine	Relies on angle units setting	$\cos^{-1}(-.5)$
Arcsine	Relies on angle units setting	$\sin^{-1}(.2)$
Arctangent	Relies on angle units setting	$\tan^{-1}(4)$
Combinations	Sequence in subset is unimportant	52 nCr 5
Common antilogarithm	Also called 10^x	10^π
Common logarithm	Base 10 logarithm	log(15.32)
Conversion to °C	From °F (5 ÷ 9 × (°F − 32))	98.6 °F converted to °C
Conversion to cm	From inches (in × 2.54)	36'' converted to cm
Conversion to DD	From deg/min/sec; the degrees setting is not required	1°6′1.8″ converted to decimal degrees
Conversion to degrees	From grads; the grads setting is required	300 grads converted to degrees
Conversion to degrees	From radians; the radians setting is required	1.5π radians converted to degrees
Conversion to DMS	From decimal degrees; the degrees setting is not required	2.012 converted to deg/min/sec format
Conversion to °F	From °C (9 ÷ 5 × °C + 32)	−15 °C converted to °F
Conversion to gallons	From liters (l ÷ 3.785411784)	30 liters converted to gallons

Keystrokes	Entry Line	Execute for Result
[3rd] [ABS] [(-)] 7.2	abs -7.2_	[ENTER] 7.2
[INV] [COS] [(-)] .5	$\cos^{-1}$ -.5_	[ENTER] 120
[INV] [SIN] .2	$\sin^{-1}$ .2_	[ENTER] 11.53695903
[INV] [TAN] 4	$\tan^{-1}$ 4_	[ENTER] 75.96375653
52 [3rd] [nCr] 5	52 nCr 5_	[ENTER] 2598960
[2nd] [10ˣ] [2nd] [π]	10^ π_	[ENTER] 1385.455731
[LOG] 15.32	log 15.32_	[ENTER] 1.185258765
98.6 [3rd] [°F-°C]	98.6 °F>°C_	[ENTER] 37
36 [2nd] [in-cm]	36 in>cm_	[ENTER] 91.44
1 [DMS] 6 [DMS] 1.8 [DMS] [2nd] [►DD]	1°6°1.8° DMS>DD_	[ENTER] 1.1005
300 [2nd] [DRG►] [3rd] [DRG>]	300 G>D_	[ENTER] 270
[(] 1.5 [×] [2nd] [π] [)] [INV] [2nd] [DRG►] [3rd] [DRG>] [3rd] [DRG>]	(1.5×π) R>D_	[ENTER] 270
2.012 [INV] [2nd] [►DD]	2.012 DD>DMS_	[ENTER] 2°0'43.2"
[(-)] 15 [INV] [3rd] [°F-°C]	-15°C>°F_	[ENTER] 5
30 [INV] [2nd] [gal-l]	30 l>gal_	[ENTER] 7.925161571

(continued)

Function	Comments	Example
Conversion to grads	From degrees; the degrees setting is required	180 degrees converted to grads
Conversion to grads	From radians; the radians setting is required	π radians converted to grads
Conversion to inches	From cm (cm ÷ 2.54)	12.7 cm converted to inches
Conversion to kg	From lb (lb × .45359237)	160 pounds converted to kilograms
Conversion to lb	From kg (kg ÷ .45359237)	.635 kilograms converted to pounds
Conversion to liters	From gallons (gal × 3.785411784)	55 gallons converted to liters
Conversion to polar	From rectangular; relies on angle units setting: degrees in this example.	(5,6) converted to polar coordinates
Conversion to radians	From degrees; the degrees setting is required	90 degrees converted to radians
Conversion to radians	From grads; the grads setting is required	100 grads converted to radians
Conversion to rectangular	From polar; relies on angle angle units setting: degrees in this example	$(1\angle -45°)$ converted to rectangular coordinates
Cosine	Relies on angle units setting	cos(120°)
Delta percent	First number is compared to second	20.4 compared to 17

Keystrokes	Entry Line	Execute for Result
180 [INV] [2nd] [DRG►] [3rd] [DRG>] [3rd] [DRG>]	180 D>G_	[ENTER] 200
[2nd] [π] [2nd] [DRG►] [3rd] [DRG>]	π R>G_	[ENTER] 200
12.7 [INV] [2nd] [in-cm]	12.7 cm>in_	[ENTER] 5
160 [2nd] [lb-kg]	160 lb>kg_	[ENTER] 72.5747792
.635 [INV] [2nd] [lb-kg]	.635 kg>lb_	[ENTER] 1.399935365
55 [2nd] [gal-l]	55 gal>l_	[ENTER] 208.1976481
[(] 5 [,] 6 [)] [INV] [2nd] [P►R]	(5,6) R>P_	[ENTER] (7.810249676 [→]* ∠50.19442891)
90 [2nd] [DRG►] [3rd] [DRG>]	90 D>R_	[ENTER] 1.570796327
100 [INV] [2nd] [DRG►] [3rd] [DRG>] [3rd] [DRG>]	100 G>R_	[ENTER] 1.570796327
[(] 1 [2nd] [∠] [(-)] 45 [)] [2nd] [P►R]	(1∠-45) P>R_	[ENTER] (0.707106781, [→]* -0.707106781)
[COS] 120	cos 120_	[ENTER] -0.5
20.4 [2nd] [Δ%] 17	20.4Δ%17_	[ENTER] 20

(continued)

Function	Comments	Example
DMS (Deg/Min/Sec) entries	DMS separator is ° in entries; maximum is 999°59′59.99″	2°0′20.8″ − 0°6′
Exchange	Valid in an equation; not valid in a formula	store 4 in A, square it, exchange it into A, and show the value in A
Factorial	Requires an integer from 0 to 69	5!
Fractional portion	Result may appear rounded to 1	frc(3.679)
Hyperbolic arccosine		$\cosh^{-1}(5)$
Hyperbolic arcsine		$\sinh^{-1}(5)$
Hyperbolic arctangent		$\tanh^{-1}(.6)$
Hyperbolic cosine		cosh(.7)
Hyperbolic sine		sinh(.8)
Hyperbolic tangent		tanh(.9)
Integer portion	Result is truncated at the decimal	int(3.679)
Natural antilogarithm	Also called e^x	$e^{-.69315}$
Natural logarithm	Base e logarithm; also called ln	ln(15.32)
Negation	Negation is a function when ahead of another function or "("	−(ln(15.32))

Keystrokes	Entry Line	Execute for Result
[(] 2 [DMS] 0 [DMS] 20.8 [DMS] [−] 0 [DMS] 6 [DMS] [)] [INV] [2nd] [►DD]	(2°0°20.8°− 0°6°) DD>DMS_	[ENTER] 1°54′20.8″
4 [STO] [ALPHA] A [x²] [3rd] [EXC] [ALPHA] A	4 Sto A² Exc A_	[ENTER] 4
[RCL] [ALPHA] A	Rcl A_	[ENTER] 16_
5 [2nd] [x!]	5!_	[ENTER] 120
[3rd] [FRC] 3.679	frc 3.679_	[ENTER] 0.679
[INV] [HYP] [COS] 5	cosh⁻¹ 5_	[ENTER] 2.29243167
[INV] [HYP] [SIN] 5	sinh⁻¹ 5_	[ENTER] 2.312438341
[INV] [HYP] [TAN] .6	tanh⁻¹ .6_	[ENTER] 0.693147181
[HYP] [COS] .7	cosh .7_	[ENTER] 1.255169006
[HYP] [SIN] .8	sinh .8_	[ENTER] 0.888105982
[HYP] [TAN] .9	tanh .9_	[ENTER] 0.71629787
[3rd] [INT] 3.679	int 3.679_	[ENTER] 3
[2nd] [eˣ] [(−)] .69315	e^−.69315_	[ENTER] 0.49999859
[LN] 15.32	ln 15.32_	[ENTER] 2.729159164
[(−)] [LN] 15.32	−ln 15.32_	[ENTER] −2.729159164

(continued)

Function	Comments	Example
Percent add-on		145 + 15% add-on
Percent discount		69.95 – 20% discount
Percent ratio		29.5 is what percent of 25?
Percentage		4% of 453
Permutations	Sequence in subset is important	8 nPr 3
Powers (universal)		$3.19^{4.73}$
Reciprocal	Also called x^{-1}	1/3.2
Roots (universal)		$\sqrt[3.9]{21.5}$
Signum	sig(x<0) = –1, sig(x≥0) = 1	sig(– 7.2)
Sine	Relies on the angle units setting	sin(11.54°)
Square		99^2
Square root		$\sqrt{2.56}$
Store	Valid in an equation; not valid in a formula	store 4 in A, square it, and show the value in A
Tangent	Relies on the angle units setting; undefined at odd multiples of 90°	tan(76°)

Keystrokes	Entry Line	Execute for Result	
145 [+] 15 [2nd] [%]	145+15%_	[ENTER]	166.75
69.95 [−] 20 [2nd] [%]	69.95−20%_	[ENTER]	55.96
29.5 [÷] 25 [2nd] [%]	29.5÷25%_	[ENTER]	118
453 [×] 4 [2nd] [%]	453×4%_	[ENTER]	18.12
8 [3rd] [nPr] 3	8 nPr 3_	[ENTER]	336
3.19 [y^x] 4.73	$3.19y^x4.73$_	[ENTER]	241.5071155
3.2 [x^{-1}]	3.2^{-1}_	[ENTER]	0.3125
3.9 [2nd] [$\sqrt[x]{\ }$] 21.5	$3.9^x\sqrt{21.5}$_	[ENTER]	2.196093807
[3rd] [SIG] [(−)] 7.2	sig -7.2_	[ENTER]	-1
[SIN] 11.54	sin 11.54_	[ENTER]	0.200052002
99 [x^2]	99^2_	[ENTER]	9801
[$\sqrt{\ }$] 2.56	$\sqrt{2.56}$_	[ENTER]	1.6
4 [STO] [ALPHA] A [x^2]	4 Sto A^2_	[ENTER]	16
[RCL] [ALPHA] A	Rcl A_	[ENTER] 4_	
[TAN] 76	tan 76_	[ENTER]	4.010780934

More Information on Specific Functions

For some of the functions in the preceding table, you may need more information to understand their operation. This additional information is presented below.

Degrees/Minutes/ Seconds Numbers

A degrees/minutes/seconds (DMS) number can have up to three digits for degrees, up to two digits for minutes, up to two digits for whole seconds, and up to two digits past the seconds decimal. The maximum DMS value is 999°59′59.99″.

The appearance of a DMS number depends on the circumstances of your viewing it:

- When entered or revisable, the punctuation is ° ° °
- When shown as a result, the punctuation is ° ′ ″

You can use a DMS number in many kinds of calculations including arithmetic, conversions to radians or grads, and trigonometric functions. When using a DMS number in a trigonometric function, set the angle units to degrees.

When you perform a calculation on DMS numbers and would like to see a DMS result, you should include the conversion to DMS. Otherwise, the result is a decimal value.

Entering a DMS number whose seconds part is 60 or greater causes the calculator to add 1 to the minutes value and subtract 60 from the seconds. Entering a DMS number whose minutes part is 60 or greater causes the calculator to add 1 to the degrees value and subtract 60 from the minutes. For instance, 1°60′90″ becomes 2°1′30″.

Because DMS notation expresses a number in subdivisions of 60ths and 3600ths, you can use a DMS number for hours/minutes/seconds calculations.

Angle Conversions

Each example includes changing the angle units setting [3rd] [DRG>] to the destination units after typing the conversion. If the setting is not adjusted, the units indicated along with the result do not match the calculated value.

Polar/Rectangular Conversions

Converting rectangular coordinates to polar results in coordinates with a positive radius and an angle that depends on the quadrant of the point.

- In the positive y quadrants, the angle is positive.
- In the negative y quadrants, the angle is negative.

This causes a point you may enter at 270° to have an angle of −90°.

Chapter 4: Calculations with Complex Numbers

A major innovation of the TI-68 is its extensive complex number capability. You have the freedom to enter complex numbers wherever they are applicable without "mode" limitations. Few other calculators even approach the versatility of complex numbers provided by the TI-68.

Chapter Contents

Complex Entries

The TI-68 is designed to recognize a rectangular or polar complex number. The punctuation joining the two parts is a signal for the calculator to handle the entry as a complex number. You can use a complex number at the same places in an expression where you might use a real number.

Parts of a Complex Number

The two perpendicular directions of the complex plane are real and imaginary. A point in the complex plane is described by a coordinate pair that states its distance from the origin in the real and imaginary directions.

(real,imaginary)

These are the rectangular coordinates. The same point also has a coordinate pair that states the magnitude and direction measured as an angle from the positive real direction.

(magnitude∠angle)

These are the polar coordinates. The calculator recognizes both forms of complex number entries and has settings for complex results to appear in either polar or rectangular form.

Instead of a coordinate pair, rectangular complex numbers are often written as a vector with a pair of terms:

a + bi in nonelectrical applications or
a + bj in electrical applications,

where i or j represents the square root of − 1. The "a" term is the real direction and the "b" term is the imaginary direction. The terms of the vector directly correspond to the rectangular coordinates.

Either part of a complex entry can be a value or an expression, such as $(\ln 6, \sqrt{2})$ and $(7^{-1}\angle\tan^{-1} 3)$. You can use a complex number as an argument for many of the functions on the calculator, as shown in the table later in this chapter.

Entering a Complex Number in Rectangular Form

The syntax for a complex number in rectangular form is:

(*real* , *imaginary*)

1. Begin with an open parenthesis.
2. Follow it with the real part.
3. Type a comma ([,]).
4. After the comma, include the imaginary part.
5. End the entry with a close parenthesis.

Entering a Complex Number in Polar Form

The syntax for a complex number in polar form is:

(*magnitude∠angle*)

1. Begin with an open parenthesis.
2. Follow it with the magnitude.
3. Type the angle separator ([2nd] [∠]).
4. After the angle separator, include the angle.
5. End the entry with a close parenthesis.

Be sure that the angle units setting matches the angle you are entering for the angle part of the number.

Viewing a Complex Number

The calculator has a setting for the form of a complex result. The two choices for this setting are rectangular or polar.

- If the rectangular form for complex results is selected, the display shows the RE indicator.
- If the polar form for complex results is selected, the display shows the PO indicator.

To change this setting, press [3rd] [RP>]. This setting affects only the way answers are displayed. Therefore, it does not limit your choice of entering a complex number in either polar or rectangular form.

Note: A polar complex number is handled internally in rectangular form. The calculator makes two conversions (first to rectangular and then back to polar) when polar results are selected. Also, the mathematics reduce the number to certain circular equivalents for rotational multiples or a negative magnitude. Consequently, a polar result is equivalent to, but may have a different appearance than, the expected result.

You can avoid most rounding discrepancies by setting the calculator for 10 digits (a selection of [2nd] [13>]).

The two parts of a complex number often will cause it to be longer than the visible display. You can use the [←] and [→] keys to scroll the display to view the entire complex number.

The parts of a complex number are shown according to the calculator's notation setting. If you select scientific or engineering notation, or if you select a fixed decimal point, both parts of a result appear in that notation.

Restrictions on Complex Entries

If you attempt to use a complex number with the following functions, an error condition occurs.

Angle conversions	Integration
Base conversions	Logical operators
Combinations	Metric conversions
Deg/min/sec conversions	Percent
Delta percent	Permutations
Factorial	Polynomial root finding
Fractional portion	Signum
Integer portion	Statistics

A complex number must be in the decimal number base.

Angle Considerations

You can convert the angle of a polar complex number from one angle unit to another. Include the appropriate angle conversion following the angle of the complex number, such as:

```
(4∠30D>R)
```

It is also appropriate for you to change the angle units setting to match the result of the conversion. The result is the same complex number, but it has new angle units.

Although you can place an angle conversion function with part of a complex number, using an angle conversion with an entire complex number causes an error. Attempting to convert a rectangular number to rectangular form or a polar number to polar form also causes an error condition.

You should select radians when using trigonometric functions with complex numbers. Otherwise, the units indicated in the display do not match the calculated values. If you select degrees or grads, complex trigonometric functions calculate a point in the complex plane as if radians were selected. However if the polar form of complex numbers is selected, the angle of a result is displayed in the currently selected angle units.

Using Complex Numbers in Functions

You perform calculations with complex numbers in a natural, straightforward sequence. Many functions are defined with a complex range outside of the real range. This enables the calculator to give you an answer instead of an error condition that you would encounter with most other calculators.

Compatible Functions

The following functions are compatible with either rectangular or polar complex entries.

- Functions after a number: square, reciprocal
- Functions before a number: negation, absolute value, square root, 10^x, e^x, logarithms, hyperbolic, inverse hyperbolic, trigonometric, inverse trigonometric
- Functions between numbers: $+$, $-$, $\times$, $\div$, y^x, $\sqrt[x]{\ }$

To use a complex argument with a function, enter the function the same as you would for a real number. The result is displayed in the currently selected complex number form, either rectangular or polar.

Example

Calculate the following.

$(3\angle 15)^2 \times 4$

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select degrees.	If D is not indicated, press [3rd] [DRG>] until it is.	_
Select polar results.	If PO is not indicated, press [3rd] [RP>] until it is.	_
Enter the expression.	[(] 3 [2nd] [∠] 15 [)] [x²] [×] 4	(3∠15)²x4_
Evaluate the expression.	[ENTER]	(36∠30)

Results of Functions

When you calculate a function of a real number:

- If the answer is a real number, a single value results.
- If the answer is complex, a pair of values in the form of a complex number results.

When you calculate a function of a complex number, the result is a complex number (except for absolute value, first coordinate, or second coordinate, which yield a real result). When the answer has an imaginary part that is zero, the imaginary part remains with the number.

Example

Calculate the following.

$2 \times \ln(\sqrt{-1}^{\sqrt{-1}})$

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select rectangular results.	If RE is not indicated, press [3rd] [RP>] until it is.	_
Enter the expression.	2 [×] [LN] [(] [√] [(-)] 1 [yˣ] [√] [(-)] 1 [)]	(√-1yˣ√-1)_
Evaluate the expression.	[ENTER]	(-3.141592654,0)

Alphabetical Table of Functions of Complex Numbers

To see an example of a desired function, find the function in the following table alphabetized by name. An answer that extends past the display is marked [→]*, meaning that to view the rest of it, you should press and hold [→]. Unless otherwise indicated, the angle units are degrees, the base is decimal, and the form of complex results is rectangular.

Function	Comments	Example
Absolute value		|(3.7,1.4)|
Addition		(3,4)+(5,-6)
Angle part of a polar complex number	This part results when the second coordinate ("imag part") of a polar complex number is isolated	imag(7.28∠35°)
Arccosine	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	$\cos^{-1}$(2.2,8.7)
Arccosine of real with complex result	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	$\cos^{-1}$(-2.3)
Arcsine	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	$\sin^{-1}$(4.9∠3.8°)
Arcsine of real with complex result	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	$\sin^{-1}$(7.8)
Arctangent	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	$\tan^{-1}$(1.1∠8.6°)
Common antilogarithm	Also called 10^x	$10^{(7.8,7.5)}$

Keystrokes	Entry Line	Execute for Result
[3rd] [ABS] [(] 3.7 [,] 1.4 [)]	abs (3.7,1.4)_	[ENTER] 3.956008089
[(] 3 [,] 4 [)] [+] [(] 5 [,] [(-)] 6 [)]	(3,4)+(5,-6)_	[ENTER] (8,-2)
[3rd] [IMAG] [(] 7.28 [2nd] [∠] 35 [)]	imag (7.28∠35)_	[ENTER] 35
[INV] [COS] [(] 2.2 [,] 8.7 [)]	$\cos^{-1}$ (2.2,8.7)_	[ENTER] [→]* (1.324578669, -2.890185428)
[INV] [COS] [(-)] 2.3	$\cos^{-1}$ -2.3_	[ENTER] [→]* (3.141592654, -1.475044781)
[INV] [SIN] [(] 4.9 [2nd] [∠] 3.8 [)]	$\sin^{-1}$ (4.9∠3.8)_	[ENTER] [→]* (1.503052568, 2.271901028)
[INV] [SIN] 7.8	$\sin^{-1}$ 7.8_	[ENTER] [→]* (1.570796327, 2.743136214)
[INV] [TAN] [(] 1.1 [2nd] [∠] 8.6 [)]	$\tan^{-1}$ (1.1∠8.6)_	[ENTER] [→]* (0.83351904, 0.074986541)
[2nd] [10ˣ] [(] 7.8 [,] 7.5 [)]	10^(7.8,7.5)_	[ENTER] [→]* (-591286.5402, -63092963.84)

(continued)

Function	Comments	Example
Common logarithm	Base 10 logarithm	log(12.22,63)
Common logarithm of real with complex result	Base 10 logarithm	log(−.28)
Conversion to polar	From rectangular; relies on angle units setting: degrees in this example.	(5,6) converted to polar form
Conversion to rectangular	From polar; relies on angle units setting	$(1\angle{-45}°)$ converted to rectangular form
Cosine	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	$\cos(1.7\angle 37.3°)$
Division		$(10 \div 3,4) \div (2 \div 3,.5)$
Hyperbolic arccosine		$\cosh^{-1}(5.1,57)$
Hyperbolic arccosine of real with complex result		$\cosh^{-1}(.75)$
Hyperbolic arcsine		$\sinh^{-1}(5.1\angle 87°)$
Hyperbolic arctangent		$\tanh^{-1}(6.24\angle 60°)$

Keystrokes	Entry Line	Execute for Result
[LOG] [(] 12.22 [,] 63 [)]	log (12.22,63)_	[ENTER] (1.807360487, [→]* 0.598982073)
[LOG] [(-)] .28	log -.28_	[ENTER] (-0.552841969, [→]* 1.364376354)
[(] 5 [,] 6 [)] [INV] [2nd] [P►R]	(5,6) R>P_	[ENTER] (7.810249676 [→]* ∠50.19442891)
[(] 1 [2nd] [∠] [(-)] 45 [)] [2nd] [P►R]	(1∠-45) P>R_	[ENTER] (0.707106781, [→]* -0.707106781)
[COS] [(] 1.7 [2nd] [∠] 37.3 [)]	cos (1.7∠37.3)_	[ENTER] (0.342315181, [→]* -1.19325429)
[(] 10 [÷] 3 [,] 4 [)] [÷] [(] 2 [÷] 3 [,] .5 [)]	(10÷3,4)÷ (2÷3,.5)_	[ENTER] (6.08,1.44)
[INV] [HYP] [COS] [(] 5.1 [,] 57 [)]	cosh^{-1} (5.1,57)_	[ENTER] (4.740260396, [→]* 1.481573812)
[INV] [HYP] [COS] .75	cosh^{-1} .75_	[ENTER] (0,0.722734248)
[INV] [HYP] [SIN] [(] 5.1 [2nd] [∠] 87 [)]	sinh^{-1} (5.1∠87)_	[ENTER] (2.312690253, [→]* 1.517401996)
[INV] [HYP] [TAN] [(] 6.24 [2nd] [∠] 60 [)]	tanh^{-1} (6.24∠60)_	[ENTER] (0.078767053, [→]* 1.432028177)

(continued)

Function	Comments	Example
Hyperbolic arctangent of real with complex result		$\tanh^{-1}(8.11)$
Hyperbolic cosine		cosh(6.8∠12°)
Hyperbolic sine		sinh(2.3,4.7)
Hyperbolic tangent		tanh(2.9,23.1)
Imaginary part	Requires rectangular complex number	imag(7.3,34)
Magnitude part of a polar complex number	This part results when the first coordinate ("real part") of a polar complex number is isolated	real(6.11∠47°)
Multiplication		(5,2)×(5,−2)
Natural antilogarithm	Also called e^x	$e^{(4.11\angle 8.7°)}$
Natural logarithm	Base e logarithm; also called ln	ln(8.2∠8.6°)
Natural logarithm of real with complex result		ln(−.31)
Negation		−(8.2∠8.6°)

Keystrokes	Entry Line	Execute for Result	
[INV] [HYP] [TAN] 8.11	tanh⁻¹ 8.11_	[ENTER] [→]*	(0.123935234, 1.570796327)
[HYP] [COS] [(] 6.8 [2nd] [∠] 12 [)]	cosh (6.8∠12)_	[ENTER] [→]*	(60.49841239, 382.1754782)
[HYP] [SIN] [(] 2.3 [,] 4.7 [)]	sinh (2.3,4.7)_	[ENTER] [→]*	(-0.061162358, -5.036834081)
[HYP] [TAN] [(] 2.9 [,] 23.1 [)]	tanh (2.9,23.1)_	[ENTER] [→]*	(1.003644476, 0.004849341)
[3rd] [IMAG] [(] 7.3 [,] 34 [)]	imag (7.3,34)_	[ENTER]	34
[3rd] [REAL] [(] 6.11 [2nd] [∠] 47 [)]	real (6.11∠47)_	[ENTER]	6.11
[(] 5 [,] 2 [)] [×] [(] 5 [,] [(-)] 2 [)]	(5,2)×(5,-2)_	[ENTER]	(29,0)
[2nd] [eˣ] [(] 4.11 [2nd] [∠] 8.7 [)]	e^(4.11∠8.7)_	[ENTER] [→]*	(47.25520105, 33.85604912)
[LN] [(] 8.2 [2nd] [∠] 8.6 [)]	ln (8.2∠8.6)_	[ENTER] [→]*	(2.104134154, 0.150098316)
[LN] [(-)] .31	ln -.31_	[ENTER] [→]*	(-1.171182982, 3.141592654)
[(-)] [(] 8.2 [2nd] [∠] 8.6 [)]	-(8.2∠8.6)_	[ENTER] [→]*	(-8.107802325, -1.226189816)

(continued)

Function	Comments	Example
Powers (universal)		$(2,3)^{(4.7,9.8)}$
Powers (universal) of real with complex result		$-8.7^{2.9}$
Real part	Requires rectangular complex number	real(22.2,4.9)
Reciprocal	Also called x^{-1}	1/(3,-4)
Roots (universal)		$^{(2,6.8)}\sqrt{(1.1\angle 9°)}$
Roots (universal) of real with complex result		$^{6.7}\sqrt{-47.8}$
Sine	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	sin(22.2,5.9)
Square	Select polar for this example	$(5\angle 40°)^2$
Square root	Select polar for this example	$\sqrt{(25\angle 80°)}$
Square root of real with complex result	Select rectangular for this example	$\sqrt{-1.69}$
Subtraction		(6.2,9) - (1,1)
Tangent	Uses radians (DRG setting ignored for complex trig but used for angles of polar numbers)	tan(7.3,1.5)

Keystrokes	Entry Line	Execute for Result	
[(] 2 [,] 3 [)] [yˣ] [(] 4.7 [,] 9.8 [)]	(2,3)yˣ(4.7,9.8)_	[ENTER] [→]*	(-0.002483967, -0.02710795)
[(-)] 8.7 [yˣ] 2.9	-8.7yˣ2.9_	[ENTER] [→]*	(-504.4430677, 163.9034883)
[3rd] [REAL] [(] 22.2 [,] 4.9 [)]	real (22.2,4.9)_	[ENTER]	22.2
[(] 3 [,] [(-)] 4 [)] [x⁻¹]	$(3,-4)^{-1}$_	[ENTER]	(0.12,0.16)
[(] 2 [,] 6.8 [)] [2nd] [ˣ√‾] [(] 1.1 [2nd] [∠] 9 [)]	(2,6.8)ˣ√(1.1∠9)_	[ENTER] [→]*	(1.025348835, -0.00681569)
6.7 [2nd] [ˣ√‾] [(-)] 47.8	6.7ˣ√-47.8_	[ENTER] [→]*	(1.588762777, 0.804828827)
[SIN] [(] 22.2 [,] 5.9 [)]	sin(22.2,5.9)_	[ENTER] [→]*	(-37.84306498, -178.5512074)
[(] 5 [2nd] [∠] 40 [)] [x²]	$(5\angle 40)^2$_	[ENTER]	(25∠80)
[√‾] [(] 25 [2nd] [∠] 80 [)]	√(25∠80)_	[ENTER]	(5∠40)
[√‾] [(-)] 1.69	√-1.69_	[ENTER]	(0,1.3)
[(] 6.2 [,] 9 [)] [−] [(] 1 [,] 1 [)]	(6.2,9)-(1,1)_	[ENTER]	(5.2,8)
[TAN] [(] 7.3 [,] 1.5 [)]	tan(7.3,1.5)_	[ENTER] [→]*	(0.093002256, 1.041231735)

Chapter 5: Variables and Memory

The calculator's memory retains stored entries even when you turn off the calculator. One kind of stored entry is variables, which are useful in many types of calculations. This chapter also presents calculator memory management.

Chapter Contents

Storing a Number

The calculator has several kinds of values, any of which can be assigned to a variable. When you retrieve a stored value, the value is the same kind as when you stored it: decimal number, complex number, DMS number, hexadecimal number, octal number, or binary number.

What is a Variable?

A variable is a substitute for a number. The variable appears in an expression as its variable name, but has a value that is used during calculations. When you assign a value to a variable, the new value replaces any previous contents. You can assign a value to a variable either by storing the value or by using the variable routine, described on page 5-12.

The Store Command

A number to be stored can be alone in the entry line, within an equation, an intermediate result in an equation, or the result of an equation. You should place the store command (Sto) either just after the desired number or where the desired intermediate result is generated. Calculations are unaffected by Sto.

To store a number, place Sto ([STO]) just after the number and spell the variable name.

- A variable name can be one, two, or three characters.
- A name must begin with a letter, but the rest of the name can be letters or numbers.
- You should avoid storing to a variable name that is already in use unless you want to replace the current value.

When you execute the equation ([ENTER]), the variable is assigned the value you are storing.

Example

Assign a value of 3 to the variable A and a value of 4 to the variable B. The example on the next page uses these variables.

Procedure	Press	Display
Store 3 in A.	3 [STO] [ALPHA] A [ENTER]	3
Store 4 in B.	4 [STO] [ALPHA] B [ENTER]	4

Retrieving a Number

You can retrieve the digits of a stored number (recall), use a command that retrieves and stores at once (exchange), or place the variable name in the expression you are entering. A variable must be defined before it can be used with recall or exchange.

Recalling a Stored Number

You can copy the digits of the number into an entry by recalling it. To recall a number:

1. Position the cursor to where you need the number and press [RCL]. The display shows **Rcl_**.
2. Type the variable name. You can revise the name like you revise other entries, except you cannot insert.
3. Either cancel or complete the recall.
   - To cancel, press [CLEAR]. The current entry returns.
   - To complete the recall, press [ENTER]. The current entry reappears with the stored number inserted.

Exchanging with a Stored Number

You can place a command within an equation that exchanges the value of the variable with a number in the calculation.

To exchange a number, place Exc ([3rd] [EXC]) just after the number and spell the variable name. When you execute the entry ([ENTER]), the variable is assigned the value you are storing, and the number that was stored is retrieved for the equation.

Representing a Stored Number

To represent a number with a variable, type the variable name where you need the number in the expression. When you execute the expression ([ENTER]), the value of the number that was stored is used in the equation.

Example

Calculate 3 + 4, as numbers and as variables.

Procedure	Press	Display
Use numbers.	3 [+] 4 [ENTER]	7
Use variables stored previously.	[ALPHA] A [+] [ALPHA] B [ENTER]	7

Shortcuts With Variables

By placing variables in your calculations, you can save time and reduce the entry length.

Advantages of Variables

The advantages of a variable representing a number are:

- When the number is some meaningful quantity, a variable name can be easier to identify than a group of digits.
- When you use the number more than once, a short variable name is easier to repeat, uses less space, and has a lower chance of incorrect digits than typing a group of several digits.
- When an intermediate result is generated, you can store it for viewing later. Because only the final result is shown after evaluating an equation, you do not see intermediate results unless they are stored.

If you are not entering an equation and wish to check the contents of variables, use the variable routine described on page 5–12.

Example 1

Calculate the area of a circle with a radius of 4.3125.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Enter the radius.	4.3125 [STO] [ALPHA] R [ENTER]	4.3125
Enter the expression for the area of a circle.	[2nd] [π] [×] [ALPHA] R [x²]	$\pi \times R^2$_
Find the area.	[ENTER]	58.42626025

Example 2

Evaluate $x^2 + 5x - 4$ for $x = 1$ and -3.

Procedure	Press	Display
Store the value of X and evaluate the expression.	1 [STO] [ALPHA] X [x²] [+] 5 [×] [ALPHA] X [−] 4 [ENTER]	2
Revise X and evaluate the expression.	[2nd] [EQU] [3rd] [INS] [(−)] 3 [3rd] [DEL] [ENTER]	-10

Performing Operations on a Stored Number

You can use the Sto function in combination with arithmetic and logic functions to perform operations on the value of a variable in memory. Such memory operations enable you to perform arithmetic or logic in memory without affecting the calculations in the equation.

Memory Arithmetic and Logic

When you perform arithmetic or logic on a variable, the result of that operation replaces the previous contents.

To use an entry value in a memory operation, place Sto and a function after it according to the following table.

Syntax	Result Stored after Pressing ENTER
entry value Sto+ *variable name*	Sum of entry value and previous contents
entry value Sto – *variable name*	Previous contents minus entry value
entry value Sto × *variable name*	Product of entry value and previous contents
entry value Sto ÷ *variable name*	Previous contents divided by the entry value
entry value Sto y^x *variable name*	Previous contents raised to the entry value power
entry value Sto $\sqrt[x]{\ }$ *variable name*	The previous contents root of the entry value
entry value Sto Δ% *variable name*	Percent change of the previous contents compared to the entry value
entry value Sto and *variable name*	Previous contents anded with the entry value
entry value Sto or *variable name*	Previous contents ored with the entry value
entry value Sto xor *variable name*	Previous contents xored with the entry value

For further information on logic operations, refer to Chapter 9.

Example 1

Find the sum of squares of 7, 8, and 9 as you add them in the variable T.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Find the sum and sum of squares.	7 [STO] [ALPHA] T [x^2] [+] 8 [STO] [+] [ALPHA] T [x^2] [+] 9 [STO] [+] [ALPHA] T [x^2] [ENTER]	194
Show the sum.	[3rd] [EXC] [ALPHA] T [ENTER]	24

Example 2

Add 4, 5, and 6 together as you also multiply them in the variable T. Then, divide the product by the sum.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Find the product and sum.	4 [STO] [ALPHA] T [+] 5 [STO] [×] [ALPHA] T [+] 6 [STO] [×] [ALPHA] T [ENTER]	15
Divide by the sum.	[STO] [÷] [ALPHA] T [ENTER]	15
Show the result.	[RCL] [ALPHA] T [ENTER]	8_

Example 3

Although the number in memory before an operation has a specific base or form, a memory operation stores the result according to the current settings and can therefore change the type of value that is stored.

Select degrees, decimal base, polar form, and 10-digit precision. Then store (15,112) and use memory arithmetic to divide it by 2.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Store the starting value.	[(] 15 [,] 112 [)] [STO] [ALPHA] A [ENTER]	(15,112)
Show contents.	[RCL] [ALPHA] A [ENTER]	(15,112)_
Perform memory division.	[CLEAR] 2 [STO] [÷] [ALPHA] A [ENTER]	2
Check memory contents.	[RCL] [ALPHA] A [ENTER]	2.37185033)_
View the rest of the answer.	[←] (hold)	(56.5∠82.371

Notice that the variable starts as a number in rectangular form, and the arithmetic changes it to polar form.

Structure of Memory

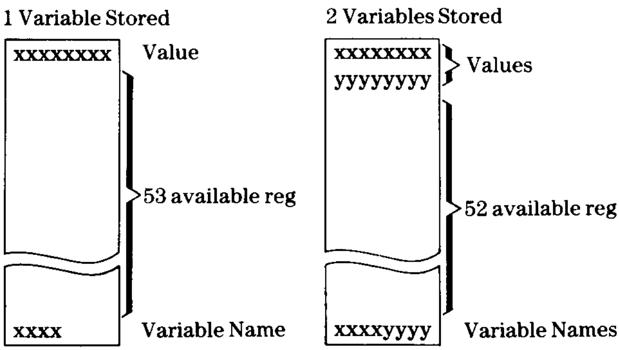
This section describes the structure of memory, which is helpful in understanding the memory capacity. The space in memory consists of stored variables, stored formulas, the statistics data set, and available registers. When no variables, formulas, or statistics are stored, all of memory is available.

Variables in Registers

The memory consists of 55 registers. The amounts of memory occupied by each type of variable are as follows:

Real decimal variable	1 1/2 registers
DMS variable	1 1/2 registers
Rectangular complex variable	2 1/2 registers
Polar complex variable	2 1/2 registers
Hexadecimal variable	1 1/2 registers
Octal variable	1 1/2 registers
Binary variable	1 1/2 registers
Companion variable of a formula	1 1/2 registers if real, or 2 1/2 registers if complex

If a register is partially occupied, it is taken off the list of available registers. However, two half-register items can share a register. Therefore, when you store one real variable, it appears to occupy two registers; but when you store two variables, they occupy three registers.



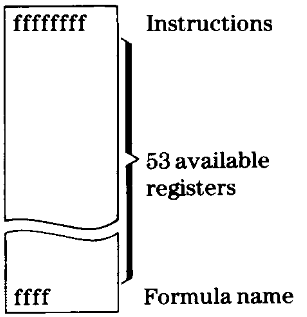
To check how the memory is occupied, press [2nd] [CHK M]. A message stating the number of registers available appears in the display. The number of available registers includes only those that are empty.

Formulas in Registers

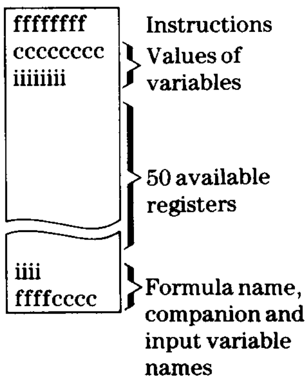
Every eight instructions or symbols of a formula occupies one register. The formula name occupies an additional one-half register.

Place the formula F = 1.234 × I in memory.

Before Evaluating:

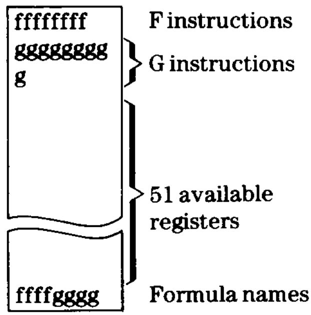


After Evaluating:

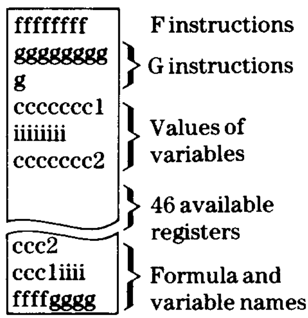


Place the formulas F = 1.234 × I and G = 1.2345 × I in memory.

Before Evaluating:



After Evaluating:



Formulas in Registers (Continued)

After a formula's name, the formula begins with a required character that associates the expression with the result variable. This required character is shown as =, but is not an ordinary character, so the calculator does not allow the cursor to be placed on the =. This required character occupies one item in the first register of a formula. Because a formula begins with this extra character, its entry limit is 79 items instead of 80 allowed in an equation.

The formula routine is described in Chapter 6.

When you have stored many formulas and the memory is almost full, you may need to clear a stored item before entering another formula. If you attempt to store a formula that does not fit in the remaining memory space, a message appears recommending that you clear a certain number of registers. The formula you attempted to store is discarded.

Memory can become too full for some activities:

- Entering simultaneous equations
- Defining a variable
- Entering a statistics data set
- Storing a formula

If you attempt one of these activities when memory space is insufficient, the calculator displays a message that recommends for you to clear a certain number of registers. After you clear them, restart the task you were performing before the message appeared.

Note: When a statistics data set is entered, it occupies 6 1/2 registers.

Managing Variables

To provide a convenient way of managing the variables you store, the calculator includes a variable routine. This two-stage routine enables you to define new variables, review all variables in alphabetical order, revise individual variables, and delete individual variables. A separate key sequence clears all variables.

Clearing All Variables

If you wish to clear all variables:

1. Press [3rd] [CVs]. The prompt **Clr YN?** appears.

2. Cancel or proceed.

   - To cancel the deletion, respond N.

   - To delete all variables, respond Y.

When to Use the Variable Routine

Because the current entry, last equation, and last answer are cleared by the variable routine, you may prefer to use this routine only at times that you no longer need the current entry, last equation, or last answer.

Beginning the Routine

To begin the variable routine, press [2nd] [VAR]. The **Name?** prompt appears. Proceed with the initial stage.

Initial Stage

In the initial stage, you can:

- Define a new variable.

- Specify an existing variable.

- Choose to list the variables.

Initial Stage, Defining a New Variable

To define a new variable, respond to the **Name?** prompt by spelling the variable name and pressing [ENTER]. Type the digits of, or an expression for the value and press [ENTER]. The value is stored in that variable. If no other variables are present, this variable is displayed. Otherwise, the next variable is displayed. Proceed to the managing stage.

Initial Stage, Specifying an Existing Variable

To specify an existing variable, respond to the **Name?** prompt by spelling the variable name and pressing [ENTER]. The variable is displayed. Proceed to the managing stage.

Initial Stage, Listing the Variables

The calculator enables you to view a listing of the variables because you may need to:

- Check which variables are in use.
- Look for a variable you might have forgotten.
- Review the contents of all variables.

To list the variables, respond to the **Name?** prompt by pressing [ENTER]. If at least one variable is already defined, the variable that is first alphabetically appears and you proceed with the managing stage. Otherwise, the **Name?** prompt remains because the calculator expects you to define a variable since none are currently defined.

Managing Stage

In the managing stage, you can:

- Advance to another variable.
- View a variable.
- Revise the value of a variable.
- Delete a variable.
- Leave the managing stage.

Managing Stage, Advancing to Another Variable

To advance to another variable, press [2nd] [NEXT], [2nd] [BACK], or [ENTER]. Going beyond the first or last variable takes you to the other end of the list. Continue with the managing stage.

Managing Stage, Viewing a Variable

To view a variable that goes past the display, scroll with [→] and [←], which repeat when held down. Continue with the managing stage.

Managing Stage, Revising the Value of a Variable

When you revise the value of a variable, first notice whether the existing value has more digits than the new value. You can save time by clearing a long value before typing the digits of a new value. You also may type an expression for the new value. Inserting and deleting are also allowed.

Then, press [ENTER], [2nd] [NEXT], or [2nd] [BACK]. Continue with the managing stage.

Managing Stage, Deleting a Variable

To delete a variable after selecting it, press [3rd] [CFV]. The prompt **Clr YN?** appears.

- To cancel the deletion, respond N. The variable reappears. Continue with the managing stage.
- To delete the variable and exit the routine, respond Y. The message **Cleared** appears.

Managing Stage, Leaving the Managing Stage

To leave the managing stage:

- And return to the initial stage, press [2nd] [VAR].
- And begin another sequenced activity such as formulas or simultaneous equations, press the key that begins the desired activity.
- And exit the variable routine, press [2nd] [EXIT].

Keystrokes	Entry Line	Execute for Result	
[(] 2 [,] 3 [)] [y^x] [(] 4.7 [,] 9.8 [)]	(2,3)y^x (4.7,9.8)_	[ENTER] [→]*	(-0.002483967, -0.02710795)
[(-)] 8.7 [y^x] 2.9	-8.7y^x2.9_	[ENTER] [→]*	(-504.4430677, 163.9034883)
[3rd] [REAL] [(] 22.2 [,] 4.9 [)]	real (22.2,4.9)_	[ENTER]	22.2
[(] 3 [,] [(-)] 4 [)] [x^-1]	(3,-4)^-1_	[ENTER]	(0.12,0.16)
[(] 2 [,] 6.8 [)] [2nd] [ˣ√‾] [(] 1.1 [2nd] [∠] 9 [)]	(2,6.8)ˣ√(1.1∠9)_	[ENTER] [→]*	(1.025348835, -0.00681569)
6.7 [2nd] [ˣ√‾] [(-)] 47.8	6.7ˣ√-47.8_	[ENTER] [→]*	(1.588762777, 0.804828827)
[SIN] [(] 22.2 [,] 5.9 [)]	sin (22.2,5.9)_	[ENTER] [→]*	(-37.84306498, -178.5512074)
[(] 5 [2nd] [∠] 40 [)] [x²]	(5∠40)²_	[ENTER]	(25∠80)
[√‾] [(] 25 [2nd] [∠] 80 [)]	√(25∠80)_	[ENTER]	(5∠40)
[√‾] [(-)] 1.69	√-1.69_	[ENTER]	(0,1.3)
[(] 6.2 [,] 9 [)] [−] [(] 1 [,] 1 [)]	(6.2,9)-(1,1)_	[ENTER]	(5.2,8)
[TAN] [(] 7.3 [,] 1.5 [)]	tan (7.3,1.5)_	[ENTER] [→]*	(0.093002256, 1.041231735)

Chapter 6: Formulas

You do not need to learn a programming language to store your own formulas in the calculator's memory. Instead, you just enter them in much the same way as performing a calculation. This chapter discusses how you can save and retrieve formulas for later use, and how to calculate the definite integral of a stored formula.

Chapter Contents

To enable you to save expressions for repeated use, the calculator includes formula storage. The alpha capability lets you type in formula names that you can remember and recognize.

What Is a Formula?

A formula conveys a fact or principle in the form of a mathematical expression. On the calculator, a formula is useful for setting one variable equal to an expression of numbers and other variables. You enter a formula almost like an ordinary calculation after beginning with a name.

Formula Names

Because you may need to store a variety of formulas and access them individually, each formula has a name. Choose a name that does not coincide with a name already in use by another formula.

- The name can be one, two, or three characters.
- The name must begin with a letter, but the rest of the name can be letters or numbers.

It is a good practice to give a formula a name that is easy to remember. You can often abbreviate the purpose of the formula into the formula name, such as abbreviating volume with VOL. If several formulas are related, you can name them similarly such as FN1, FN2, and FN3. You also can name a formula so that it is easy to type such as A. You can choose names to fit your needs.

Versatility of Formulas

Formulas can manipulate any kind of values you can enter into an equation including real numbers; complex numbers; deg/min/sec numbers; and hexadecimal, octal, and binary numbers. The capacity of a formula is 79 operations and digits.

Note: You can often rewrite an unusually long formula to occupy less space. Refer to "Structure of Memory" in Chapter 5 for a discussion of how a formula occupies memory.

Because a formula needs to use the values of variables that exist when the formula begins executing, a formula cannot contain operations that change or define the values of variables, such as store or exchange.

A formula can share variables with other formulas, and perform further calculations on an earlier result. This enables you to:

- Write a separate formula for each result when a problem requires several answers.

- Write a long formula as shorter, related formulas.

The calculator includes a special routine that helps you manage formulas. The formula routine is described in the next section.

Entering, Evaluating, or Integrating Formulas

The calculator's built-in formula routine provides a convenient way of managing the formulas you store. This four-stage routine enables you to accomplish all the tasks that are possible with formulas on the calculator, including evaluating and integrating a formula.

Beginning the Routine

To begin the formula routine, press [2nd] [FMLA]. The prompt **Name?** appears. Proceed with the initial stage.

Initial Stage

In the initial stage, you can:

- Enter a new formula.
- Specify an existing formula.
- Choose to list the formulas.

Initial Stage, Entering a New Formula

To enter a new formula, respond to the **Name?** prompt by spelling the formula name and pressing [ENTER]. If a formula with this name is already entered, either clear the formula or choose a different name. If this name is available, type the expression for the formula. When the formula is complete, you can:

- Evaluate the formula. Press [SOLVE] and proceed with the input stage.
- Evaluate the formula. Press [ENTER] and the prompt **Solve YN?** appears. Press Y and proceed with the input stage.
- Store the formula and leave the formula routine. Press [ENTER] and the prompt **Solve YN?** appears. Press N.
- Store the formula and view other currently stored formulas. Press [2nd] [NEXT] or [2nd] [BACK]. Proceed with the managing stage.
- Leave the formula routine without storing the formula. Press [2nd] [EXIT].

Initial Stage, Specifying an Existing Formula

To specify a formula, respond to the **Name?** prompt by spelling the formula name. Then:

- If you are evaluating the formula, press [SOLVE]. Proceed with the input stage.
- If you are viewing the formula, press [ENTER]. Proceed with the managing stage.

Initial Stage, Listing the Formulas

The calculator enables you to view a listing of the formulas because you may need to:

- Check which formulas are entered.
- Look for a formula you might have forgotten.

To list the formulas, respond to the **Name?** prompt by pressing [ENTER]. If no formulas are currently stored, the **Name?** prompt remains because the calculator expects you to enter a new formula. Otherwise, the first formula in alphabetical order appears and you proceed with the managing stage.

Managing Stage

In the managing stage, you can:

- Advance to another formula.
- View a formula.
- Revise a formula.
- Delete a formula.
- Leave the managing stage.

Managing Stage, Advancing to Another Formula

To advance to another formula, press [2nd] [NEXT] or [2nd] [BACK]. Continue with the managing stage.

Managing Stage, Viewing a Formula

To view a formula that goes past the display, scroll with [←] and [→], which repeat when held down. Continue with the managing stage.

Managing Stage, Revising a Formula

To revise the current formula, modify the expression. When the formula is satisfactory, you can:

- Evaluate or integrate the formula. Press [SOLVE] and proceed with the input stage.
- Evaluate or integrate the formula. Press [ENTER] and the prompt **Solve YN?** appears. Press Y and proceed with the input stage.
- Store the formula and leave the formula routine. Press [ENTER] and the prompt **Solve YN?** appears. Press N.
- Store the formula and view other formulas. Press [2nd] [NEXT] or [2nd] [BACK]. Continue with the managing stage.
- Cancel the changes and leave the formula routine. Press [2nd] [EXIT].

Managing Stage, Deleting a Formula

To choose to delete the current formula, press [3rd] [CFV] or [CLEAR] [ENTER]. The prompt **Clr YN?** appears.

- To cancel the deletion, respond N. Continue with the managing stage.
- To confirm the deletion and exit the formula routine, respond Y.

Managing Stage, Leaving the Managing Stage

To leave the managing stage:

- And proceed with the input stage for evaluating or integrating the current formula, press [SOLVE].
- And return to the initial stage, press [2nd] [FMLA].
- And begin another sequenced activity such as polynomial roots or simultaneous equations, press the key for the desired activity.
- And exit the formula routine, press [2nd] [EXIT].

Input Stage

By choosing to solve, you proceed with a sequence that prompts you for the value of each variable. In this stage, you can:

- Enter the values of the variables and choose to evaluate the formula.
- Accept the values of the variables and skip to the evaluation of the formula.
- Enter each variable either as the independent variable, or as a value, and choose to integrate the formula.

Input Stage, Entering Values

The prompting sequence that leads to evaluation is:

1. Supply or change the value of each variable.
   - When the existing value is correct, leave it as is.
   - When you revise the value of the variable, first notice whether the existing value has more digits than the new value. You can save time by clearing a long value before typing the digits of a new value. You also may type an expression for the new value. Inserting and deleting are also allowed.

   Then, press [ENTER]. The next variable appears.
2. Repeat the previous step until all variables are entered or go to "Input Stage, Skipping to the Evaluation."
3. After the last variable is entered, the prompt **Review YN?** appears.
   - To review the variables, respond Y. Return to step 1, above.
   - To evaluate the formula, respond N. Proceed with the output stage.

Input Stage, Skipping to the Evaluation

To accept the variables after they are all defined and skip to the evaluation, press [SOLVE]. You can also use [SOLVE] in place of [ENTER] to skip to the evaluation after modifying or accepting a variable. Proceed with the output stage.

Input Stage, Entering Values Before Integration

An integration example appears on page 6-18. The prompting sequence that leads to integration is:

1. If this is the independent variable of integration (the one written after "d" at the end of your integral):

   a. First notice whether a value is already assigned to this variable. If so, clear it so it can serve as the independent variable. Declare the variable as independent by pressing [3rd] [dx] [ENTER]. The prompt **low = ?** appears.

   b. Enter a value for the lower limit and press [ENTER]. The prompt **up = ?** appears.

   c. Enter a value for the upper limit and press [ENTER]. The prompt **intrv = ?** appears.

   d. Decide the number of intervals. While a small number of intervals improves execution speed, a greater number of intervals improves the accuracy, but takes longer. Typically, the number of intervals ranges from 4 to 20, but can be as many as 99.

      Specify the number of intervals and press [ENTER]. If other variables occur after this one in the expression, a prompt for the value of the next variable appears.

   You may declare only one variable as the independent variable. You must assign values to the rest of the variables.

(continued)

Input Stage, Entering Values Before Integration (Continued)

If this is an ordinary numeric variable, supply or change the value of each variable.

- When the existing value is correct, leave it as is.
- When you revise the value of the variable, first notice whether the existing value has more digits than the new value. You can save time by clearing a long value before typing the digits of a new value. You also may type an expression for the new value. Inserting and deleting are also allowed.

Then, press [ENTER]. The next variable appears. All but one variable must be assigned a value.

2. Repeat the previous step until all variables are entered or go to "Input Stage, Skipping to the Evaluation."
3. After the last variable, the prompt **Review YN?** appears.
   - To review the variables, respond Y. Return to step 1.
   - To proceed with integration, respond N. Go to the output stage.

Output Stage

While the calculation is being performed, you may need to wait briefly before the result appears in the display. When execution stops, either:

- The result appears (the formula's evaluation or integral) and the formula routine is exited. To repeat the input stage, press [SOLVE].
- The message **Error** appears. To show the formula with the cursor positioned at the error, press [2nd] [EQU] and go to the managing stage. To exit the formula routine, press [CLEAR].

Application: Interpolation

Because reference tables are incremented at values that are near values you are calculating or measuring, but rarely exactly equal, you usually need to interpolate between the tabulated values.

The Formula

To interpolate, you must know:

- X1, the increment of the table above the desired value.
- Y1, the reading in the table for X1.
- X2, the increment of the table below the desired value.
- Y2, the reading in the table for X2.
- XD, the number at which the desired reading is found.

The formula that interpolates the desired reading, YD, is:

YD = (XD − X2) ÷ (X1 − X2) × (Y1 − Y2) + Y2

Example

The values listed in a table include:

X	Y
1.04	0.8508
1.05	0.8531

Interpolate for XD = 1.044.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Begin formula routine.	[2nd] [FMLA]	Name?
Type the formula. [ALPHA] Y [ALPHA] D [ENTER] [(] [ALPHA] X [ALPHA] D [−] [ALPHA] X2 [)] [÷] [(] [ALPHA] X1 [−] [ALPHA] X2 [)] [×] [(] [ALPHA] Y1 [−] [ALPHA] Y2 [)] [+] [ALPHA] Y2 [ENTER]		Solve YN?
Evaluate the formula.	Y	XD=?
Enter the variable.	1.044 [ENTER]	X2=?
Enter the variable.	1.05 [ENTER]	X1=?
Enter the variable.	1.04 [ENTER]	Y1=?
Enter the variable.	0.8508 [ENTER]	Y2=?
Evaluate.	0.8531 [SOLVE]	YD= 0.85172

Repeating a Formula for a Changing Variable

Sometimes you need to evaluate a formula for several values of the same variable. This section describes how to repeat a formula while pressing the fewest possible keys.

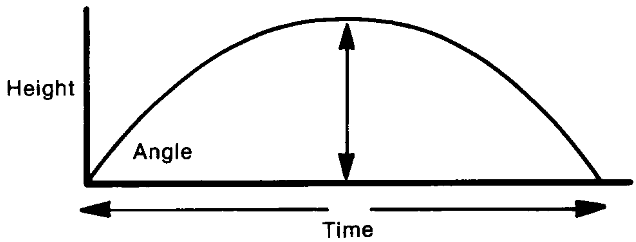
Suggestions

Plan ahead for the variable that will change through several evaluations. If workable, arrange the formula so that the changing variable occurs ahead of all other variables. This causes the prompting sequence to place the changing variable first. If the rest of the variables need no changes, you can skip to the evaluation by using [SOLVE].

When the result appears, do not press [CLEAR]. That would end the repetition pattern. After you view a result, press [SOLVE] to repeat the input prompting sequence.

Example

The initial angle of elevation and the firing velocity determine the flight time of a projectile that is fired from ground level and travels over level terrain.



T = sin ANG × 2 × V ÷ G

ANG is the initial angle of elevation.
V is the firing velocity in meters per second.
G is acceleration of gravity in meters per second^2.

Find T for the angles 20°, 60°, and 89° when V is 20 and G is 9.80665.

Example (Continued)

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Set angle units to degrees.	If D is not indicated, press [3rd] [DRG>] until it is.	_
Begin formula routine.	[2nd] [FMLA]	Name?
Proceed with formula.	[ALPHA] T [ENTER] [SIN] [2nd] [A•LOCK] ANG [ALPHA] [×] 2 [×] [ALPHA] V [÷] [ALPHA] G [ENTER]	Solve YN?
Evaluate the formula.	Y	ANG=?
Enter first angle.	20 [ENTER]	V=?
Enter velocity.	20 [ENTER]	G=?
Enter gravity.	9.80665 [ENTER]	Review YN?
Evaluate without review.	N	T=1.395053941
Repeat for next angle.	[SOLVE]	ANG=20
Enter next angle.	60 [SOLVE]	T= 3.53240058
Repeat for next angle.	[SOLVE]	ANG=60
Enter next angle.	89 [SOLVE]	T=4.078243621

How a Formula Can Use Results of Other Formulas

You can use the result of a formula as input in another formula.

Advantages of Using a Result in Another Formula

You sometimes need to perform some calculations to get one result, but then need to perform further calculations to arrive at a final result. By using one formula to find the first result and using another formula to perform subsequent calculations, you get to view both results. Also, the second formula does not have to repeat the calculations of the first formula.

When you are working with an unusually long formula that does not fit in 79 symbols, you can rewrite it as separate formulas that perform their own parts of the calculation sequence. After you evaluate the first of the smaller formulas, you should accept the result unchanged in the prompting sequence for the second formula.

When two formulas contain identical expressions, that part of both formulas can be replaced with a variable that represents the expression common to both formulas. By writing a separate formula for a recurring expression, you can save memory space.

Companion Variable of a Formula

After a formula is evaluated, it has a companion variable with the same name as the formula. When the name of a formula is used in a second formula, the most recent evaluation of the first formula is retrieved. There is no transfer of execution from one formula to another.

Example

Calculate the work done to lift a full elevator 400 meters at a rate of 2 meters per second. The elevator is powered by a 500000 w motor. Also calculate the capacity of the elevator (102 kg mass when empty) for 60 kg boxes.

Work (Newton m) is WK. WK = P × D ÷ V	P is power of motor (watts). D is distance (meters). V is velocity (meters/sec).
Number of boxes is NB. NB = (WK ÷ D ÷ G − ME) ÷ MB	G is grav. acceleration. ME is mass of empty elevator. MB is mass of 1 box (kg).

Example (Continued)

Note: The variables V and G are defined in the previous example. This example assumes you have not altered these variables after finishing the previous example.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Begin formula routine.	[2nd] [FMLA]	Name?
Proceed with first formula. [ALPHA] W [ALPHA] K [ENTER] [ALPHA] P [×] [ALPHA] D [÷] [ALPHA] V [SOLVE]		P=?
Enter power.	500000 [ENTER]	D=?
Enter distance.	400 [ENTER]	V=20
Enter velocity and evaluate formula.	[CLEAR] 2 [SOLVE]	WK=100000000
Begin formula routine.	[2nd] [FMLA]	Name?
Proceed with next formula. [ALPHA] N [ALPHA] B [ENTER] [(] [ALPHA] W [ALPHA] K [÷] [ALPHA] D [÷] [ALPHA] G [−] [ALPHA] M [ALPHA] E [)] [÷] [ALPHA] M [ALPHA] B [SOLVE]		WK=100000000
Accept the work.	[ENTER]	D=400
Accept the distance.	[ENTER]	G=9.80665
Accept gravity.	[ENTER]	ME=?
Enter mass of elevator.	102 [ENTER]	MB=?
Enter mass of one box and evaluate formula.	60 [SOLVE]	NB=423.1817554

The elevator capacity is 423 boxes of this weight.

Integration Procedure

The procedure for calculating an integral is much like the one for evaluating a formula. However, you declare one of the variables to be "dX" instead of assigning it a value. This integration procedure is shortened from the formula routine on page 6-4.

Procedure

Follow this procedure to integrate a function.

1. Check the settings of the calculator to be sure that the decimal number system is selected. If angles are involved, refer to the last topic of this chapter.

2. To integrate a new function, press [2nd] [FMLA], spell the function name, press [ENTER], and enter the expression for the function.

   To integrate an existing function, press [2nd] [FMLA] and specify the formula name in either of two ways:

   - Spell the name of the formula.
   - Press [ENTER] to see the list of formulas and advance through the list with [2nd] [NEXT] and [2nd] [BACK] until the desired formula appears.

Procedure (Continued)

3. Press [SOLVE]. The calculator prompts you for the value of each variable.

   ► If the prompted variable is the independent variable (the one written after "d" at the end of your integral), press [3rd] [dx] [ENTER]. Then provide the lower and upper limits for the integral. You also specify the number of intervals.

   ► If the prompted variable is not the independent variable, enter a specific value for the variable.

   Only one variable may be designated as the independent variable. The rest must be specific values.

   If you need to quit during the entry sequence, you can press [2nd] [EXIT] and the sequence will stop.

4. When the prompting sequence is complete, the question **Review YN?** appears.

   ► To review the variables, respond Y.

   ► To integrate the formula, respond N.

5. While the calculation is being performed, you may need to wait briefly before the result appears in the display. When execution stops, either:

   ► The integral is calculated.

   ► An error is found and **Error** appears in the display. Press [2nd] [EQU] to show the formula with the cursor positioned at the error.

Application: Integrating a Simple Polynomial

To demonstrate the accuracy of the calculator's integration method, this example integrates a simple function both manually and on the calculator.

Integrating Manually

Integrate the function $y = 4x^3$ with respect to x, using limits of .5 and 1.5.

$$y = \int_{.5}^{1.5} 4x^3 dx$$

The integral is $y = (x^4)_{.5}^{1.5} = 1.5^4 - .5^4 = 5$.

Integrating on the Calculator

Place the function $4x^3$ in memory with the name FN1 so that you can recognize it as "function 1." Specify four intervals.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Enter the formula.	[2nd] [FMLA] [ALPHA] F [ALPHA] N 1 [ENTER] 4 [×] [ALPHA] X [yˣ] 3	FN1=4×Xyˣ3_
Proceed with integration.	[SOLVE]	X=?
Declare X to be the independent variable.	[3rd] [dx] [ENTER]	low=?
Enter the lower limit.	.5 [ENTER]	up=?
Enter the upper limit.	1.5 [ENTER]	intrv=?
Enter the number of intervals.	4 [ENTER]	Review YN?
Calculate the result.	N	FN1= 5

The calculated result, 5, is the same as the result of integrating manually.

Application: Integrating the Normal Curve

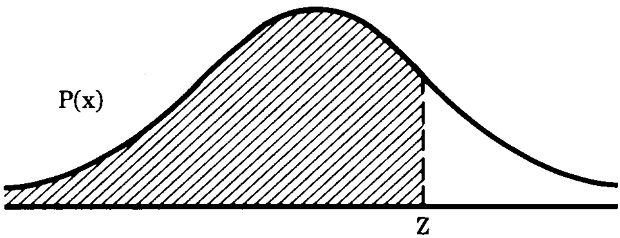
Even though the normal curve has no integral function, you can enter the formula for the normal curve and the calculator can determine its area between given z scores.

Normal Curve Formula

The normal curve describes the probability for the amount of a trait found in an individual when the trait is randomly distributed among the members of a large population.

$$P(x) = \sigma^{-1}(2\pi)^{-.5}\int_a^b e^{-.5((x-\text{mean})/\sigma)^2}\,dx$$

The integration limits a and b are the two z scores that bound the area. The horizontal axis is used to position z scores, which are stated as a number of standard deviations. A z score of 1 is one standard deviation above the mean. A z score of −2 is two standard deviations below the mean.



Example

Calculate the area between − 1 and + 1 when the standard deviation is 1 and the mean is zero.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Write the formula for P(x). [2nd] [FMLA] [ALPHA] P [ALPHA] X [ENTER] [2nd] [A•LOCK] SIG [ALPHA] [x⁻¹] [×] [(] 2 [×] [2nd] [π] [)] [yˣ] [(-)] .5 [×] [2nd] [eˣ] [(] [(-)] .5 [×] [(] [(] [ALPHA] X [−] [ALPHA] M [ALPHA] N [)] [÷] [2nd] [A•LOCK] SIG [ALPHA] [)] [x²] [)] [ENTER]		Solve YN?
Choose to solve.	Y	SIG=?
Enter standard deviation of 1.	1 [ENTER]	X=?
Declare independent variable.	[3rd] [dx] [ENTER]	low=?
Enter the lower limit.	[(-)] 1 [ENTER]	up=?
Enter the upper limit.	1 [ENTER]	intrv=?
Enter the intervals.	3 [ENTER]	MN=?
Enter mean of 0.	0 [ENTER]	Review YN?
Proceed with execution.	N	PX=0.682758614

About 68% of the area is within one standard deviation of the mean.

Integration Function Considerations

You can use the calculator to integrate a function between definite bounds. The result is a value for the area under the curve.

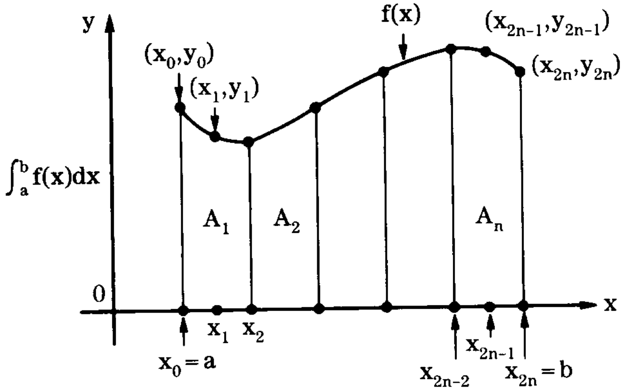
Requirements for Your Function

Because the calculator integrates by areas of intervals, you can use the calculator's integration feature on an integral you might otherwise evaluate manually, or even on a function for which no integral function exists.

A function that the calculator is to integrate must be entirely real. Complex numbers are not allowed. The decimal number base is required also.

How the Calculator Integrates

A fundamental way of integrating involves finding the antiderivative. For example, the antiderivative of $3x^2$ is x^3. The calculator does not find the antiderivative, nor does it arrive at any modification of the function before evaluating the integral. Instead, it evaluates your function at several sample points and uses Simpson's rule for determining the area in intervals.



How the Calculator Integrates (Continued)

The area is divided into two subintervals per interval, so entering n intervals yields 2n subintervals. The subinterval boundaries are at $x_0(=a), x_1, \ldots, x_{2n-1}, x_{2n}(=b)$. The even-numbered subinterval boundaries are also interval boundaries. The odd-numbered boundaries are interval midpoints.

The area of each interval is calculated by taking a weighted average of the boundary values and midpoint $(y_0+4y_1+y_2)/6$, and multiplying by the width. Because the midpoint is more representative of the interval height than a boundary, it has the greatest weighting (4/6). Each boundary has a lesser weighting (1/6) because the boundary may be deceptively high or low. The width of each subinterval is $h=(b-a)\div 2n$, making the width of each interval 2h.

Simpson's approximation for the area of the first interval is $A_1=(y_0+4y_1+y_2)/6\times 2h$ which is simplified as $A_1=h/3\times(y_0+4y_1+y_2)$.

The combined areas of the intervals $A_1+A_2+\ldots+A_n$ results in the area under the curve. In calculating the area of each interval, this method multiplies by h/3, which can be factored out when combining areas. After combining the sums of boundaries and midpoints, Simpson's rule is stated as:

$$\int_a^b f(x)dx =$$

$$h/3\times(y_0+4y_1+2y_2+4y_3+\ldots+2y_{2n-2}+4y_{2n-1}+y_{2n})$$

Even terms (except for the first and last) have a weighting of 2 because they apply to both intervals that are adjacent to that boundary. The first and last terms have a weighting of 1 because they are unshared boundaries. Odd terms have a weighting of 4 because they are interval midpoints.

Trigonometric Integrals

A trigonometric expression is not integrated manually according to a simple set of rules as are polynomials. Therefore, you often need to look up the integral in a table. To evaluate the integral between limits, you find its value at the upper limit and subtract its value at the lower limit. A table of trigonometric integrals is based on radian angles. To obtain the same answer when integrating on the calculator, the angle units must be set to radians before performing the integration.

Although a function may not contain any trigonometric functions, its integral may be an inverse trigonometric function. For such a function, the answer is in terms of radians, regardless of the angle units setting. For example, the indefinite integral of $(1/\sqrt{(2x-x^2)})$ is $\cos^{-1}(1-x)$. If you evaluate $\int_1^{1.5}(1/\sqrt{(2x-x^2)})dx$ with the integration feature using 25 intervals, you get 0.523598776 regardless of the angle units. But if you evaluate $(\cos^{-1}(1\text{-}x))_1^{1.5}$, you must set the calculator to radians to get the same answer (0.523598776).

Be sure to select the angle units that apply to your function (usually radians) before performing the integration.

Chapter 7: Simultaneous Equations

You can use the calculator to find the solutions to a set of second- through fifth-order simultaneous equations. The system may be real or complex. This chapter explains how to use the simultaneous equation solution feature.

Chapter Contents

Equation System Conventions

A system of simultaneous equations can be written with its coefficients in an arrangement of rows and columns. A row/column subscript identifies each coefficient.

Pattern of Coefficients

A set of simultaneous equations for which the calculator is to find the solutions should be written with the variables uniformly on the left and the constant terms on the right.

Fifth Order System

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 + a_{15}x_5 = b_1$$
$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 + a_{25}x_5 = b_2$$
$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{34}x_4 + a_{35}x_5 = b_3$$
$$a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 + a_{45}x_5 = b_4$$
$$a_{51}x_1 + a_{52}x_2 + a_{53}x_3 + a_{54}x_4 + a_{55}x_5 = b_5$$

Fourth Order System

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 + a_{14}x_4 = b_1$$
$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 + a_{24}x_4 = b_2$$
$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 + a_{34}x_4 = b_3$$
$$a_{41}x_1 + a_{42}x_2 + a_{43}x_3 + a_{44}x_4 = b_4$$

Third Order System

$$a_{11}x_1 + a_{12}x_2 + a_{13}x_3 = b_1$$
$$a_{21}x_1 + a_{22}x_2 + a_{23}x_3 = b_2$$
$$a_{31}x_1 + a_{32}x_2 + a_{33}x_3 = b_3$$

Second Order System

$$a_{11}x_1 + a_{12}x_2 = b_1$$
$$a_{21}x_1 + a_{22}x_2 = b_2$$

Remember to include a zero coefficient for any terms that are missing from the equations.

Solution Procedure for Simultaneous Equations

The calculator's built-in feature for solving a system of simultaneous equations keeps you aware of the meaning of each entry and result. The calculator prompts you for each coefficient, and it labels each item of the solution set.

Preliminary Stage

Follow the preliminary stage of the procedure before proceeding with the solutions to a system of simultaneous equations.

1. Check the settings of the calculator to be sure that the decimal number system is selected.
2. Examine the equations to identify their order and coefficients.
3. Press [2nd] [SIMUL]. The calculator prompts you for the number of equations in the system.
4. Respond with the number of equations, 2, 3, 4, or 5. The calculator asks **Complex YN?**.

   Note: If any complex coefficient is present, a complex system is appropriate because an error condition occurs if you enter a complex coefficient in a real system of equations.

5. To specify that your system is complex, respond Y. To specify that your system is real, respond N.

   ► If memory is insufficient for this order and type of system, the calculator recommends that you clear a certain number of registers. When this message appears, you must decide what to clear. Your choices are:

     To gain 1 to 3 registers, clear a variable.
     To gain 1 to 11 registers, clear a formula.
     To gain 6 or 7 registers, clear the statistics data.

     Refer to page 5–9 for details of memory space. After clearing enough registers, return to step 3 of this stage.

(continued)

Preliminary Stage (Continued)

- If there is enough memory for this order and type of system, the calculator prompts you for the first coefficient, a_{11}. Proceed with the input stage below.

Input Stage

Follow the input stage of the procedure to enter the coefficients of a system of simultaneous equations.

1. Respond with the value of each coefficient in the row. You can enter digits, recall a value, or enter an expression for the value of a coefficient.

   If you enter an expression for the value of a coefficient, it should not use the store and exchange functions, nor should it exceed six pending real values or three pending complex values.

   After you type in a coefficient, press [ENTER].

   If you need to quit during coefficient entry, you can press [2nd] [EXIT] or [2nd] [OFF] and the sequence will stop. You can also leave the simultaneous equations sequence to start a different sequence by pressing [2nd] [VAR], [2nd] [FMLA], or [2nd] [POLY].

   Continue entering the coefficients until you have completed the row. After you enter a row of "a" coefficients, the prompt for the "b" coefficient of the row appears.

2. Respond with the value of the "b" coefficient.

   - If there are more coefficients, the calculator prompts you for the first coefficient in the next row. Go to step 1 of the input stage.

   - If there are no more coefficients, the prompt **Review YN?** appears.

Input Stage (Continued)

3. To review the coefficients, respond Y. The first coefficient appears. Go to step 4 of the input stage.

   To skip reviewing the coefficients and accept their current values, respond N and go to the output stage.

4. When reviewing coefficients, you can advance to other coefficients by pressing [2nd] [NEXT], [2nd] [BACK], or [ENTER]. When you revise the value of a coefficient, first notice whether the existing value has more digits than the new value. You can save time by clearing a long value before typing the digits of a new value. You also may type an expression for the new value. Inserting and deleting are also allowed.

   Then, to accept the revision:

   - And accept all other coefficients, press [SOLVE] and go to the output stage.
   - And continue with the next coefficient, press [ENTER].

   Continue reviewing the coefficients until they are satisfactory. To obtain the results, press [SOLVE]. Proceed with the output stage.

   If you advance past the last coefficient, the prompt **Review YN?** appears. Go back to step 3.

Output Stage

The calculator computes the solutions to the system. If the system is singular, an error condition occurs. Otherwise, the calculator displays the first solution, x_1.

If the solution goes past the display, you can scroll to the rest of the value with [←] and [→].

If you need to use a solution in later calculations, you should store it as a variable before leaving the solution set.

To view other solutions, press [ENTER], [2nd] [NEXT], or [2nd] [BACK].

To leave the solution set, press [2nd] [EXIT] or any key other than those used for viewing results: [←], [→], [ENTER], [2nd] [NEXT], [2nd] [BACK], or [STO].

Application: Analyzing a Resistance Network

The techniques of node analysis or mesh analysis can be used to analyze a resistance network. This example uses node analysis to solve the voltages at all nodes in a circuit of resistors. To use node analysis, write equations based on the fact that the algebraic sum of currents flowing into a node is equal to zero.

Principle

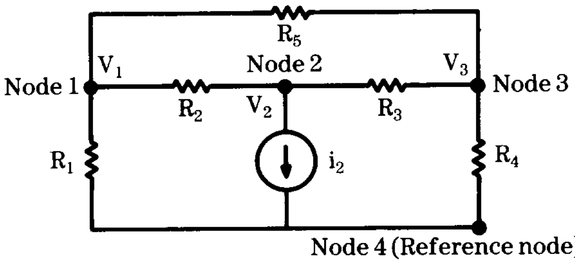
Any circuit has two or more nodes. Components are connected between the nodes to form current paths. The current entering a node must equal the current leaving the node. One node is the reference node for voltage measurements across components. The current in an individual current path is defined by either of two situations.

- The reciprocal of the resistance (1/R) multiplied by the voltage (v) across that component.
- The value of a current source in that path.

To write a system of simultaneous equations describing the circuit, place all the $1/R \times v$ terms on one side of the = sign, and place all the current source terms on the other side.

Example

The following circuit has four nodes.



The current equations at the nodes are:

Node 1: $$\frac{1}{R_1} v_1 + \frac{1}{R_2}(v_1 - v_2) + \frac{1}{R_5}(v_1 - v_3) = 0$$

Node 2: $$\frac{1}{R_2}(v_2 - v_1) + \frac{1}{R_3}(v_2 - v_3) = -i_2$$

Node 3: $$\frac{1}{R_4} v_3 + \frac{1}{R_3}(v_3 - v_2) + \frac{1}{R_5}(v_3 - v_1) = 0$$

(continued)

Example (Continued)

Regrouping the coefficients of voltage yields:

$$\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_5}\right)v_1 + \left(\frac{-1}{R_2}\right)v_2 + \left(\frac{-1}{R_5}\right)v_3 = 0$$

$$\left(\frac{-1}{R_2}\right)v_1 + \left(\frac{1}{R_2} + \frac{1}{R_3}\right)v_2 + \left(\frac{-1}{R_3}\right)v_3 = -i_2$$

$$\left(\frac{-1}{R_5}\right)v_1 + \left(\frac{-1}{R_3}\right)v_2 + \left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}\right)v_3 = 0$$

Writing the system of equations in matrix form yields:

$$\begin{bmatrix} \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_5}\right) & \left(\frac{-1}{R_2}\right) & \left(\frac{-1}{R_5}\right) \\ \left(\frac{-1}{R_2}\right) & \left(\frac{1}{R_2} + \frac{1}{R_3}\right) & \left(\frac{-1}{R_3}\right) \\ \left(\frac{-1}{R_5}\right) & \left(\frac{-1}{R_3}\right) & \left(\frac{1}{R_3} + \frac{1}{R_4} + \frac{1}{R_5}\right) \end{bmatrix} \begin{bmatrix} v_1 \\ v_2 \\ v_3 \end{bmatrix} = \begin{bmatrix} 0 \\ -i_2 \\ 0 \end{bmatrix}$$

The column on the right is called a solution vector.

Example (Continued)

Let the components in the circuit be:

$R_1 = 1000\ \Omega$
$R_2 = 400\ \Omega$
$R_3 = 200\ \Omega$
$R_4 = 85\ \Omega$
$R_5 = 2000\ \Omega$
$i_2 = 10$ ma

Find v_1, v_2, and v_3.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Begin entry sequence.	[2nd] [SIMUL]	Equa 2–5?
Specify 3rd order.	3	Complex YN?
Specify real.	N	a11=?
Enter the row 1, column 1 coefficient.	1000 [x⁻¹] [+] 400 [x⁻¹] [+] 2000 [x⁻¹] [ENTER]	a12=?
Enter the coefficient.	[(-)] 400 [x⁻¹] [ENTER]	a13=?
Enter the coefficient.	[(-)] 2000 [x⁻¹] [ENTER]	b1=?
Enter the row 1 solution vector coefficient.	0 [ENTER]	a21=?
Enter the coefficient.	[(-)] 400 [x⁻¹] [ENTER]	a22=?

(continued)

Example (Continued)

Procedure	Press	Display
Enter the coefficient.	400 [x⁻¹] [+] 200 [x⁻¹] [ENTER]	a23=?
Enter the coefficient.	[(-)] 200 [x⁻¹] [ENTER]	b2=?
Enter the row 2 solution vector coefficient.	[(-)] 10 [EE] [(-)] 3 [ENTER]	a31=?
Enter the coefficient.	[(-)] 2000 [x⁻¹] [ENTER]	a32=?
Enter the coefficient.	[(-)] 200 [x⁻¹] [ENTER]	a33=?
Enter the coefficient.	200 [x⁻¹] [+] 85 [x⁻¹] [+] 2000 [x⁻¹] [ENTER]	b3=?
Enter the row 3 solution vector coefficient.	0 [ENTER]	Review YN?
Select not to review.	N	x1=-1.544391942
View the next solution.	[2nd] [NEXT]	x2=-2.327281771
View the next solution.	[2nd] [NEXT]	x3=-0.718726685
Leave the solution set.	[2nd] [EXIT]	_

The voltages at the three nodes with respect to the reference node are approximately $v_1 = -1.54$, $v_2 = -2.33$, and $v_3 = -0.72$ volts.

Application: Analyzing an Impedance Network

The techniques of node analysis or mesh analysis can be used to analyze an impedance network. This example uses mesh analysis to solve the currents in all loops in a circuit of components whose impedances are not purely resistive. Complex coefficients describe resistors, capacitors, and inductors.

Principle

Circuits are often designed to handle electrical signals that oscillate at specific frequencies. A resistor has an impedance that is purely real and unaffected by frequency. A capacitor or inductor has an impedance that is purely imaginary and varies with frequency. The imaginary part of impedance is called reactance.

Capacitive reactance = $-1/(2\pi fC)\Omega$

Inductive reactance = $2\pi fL\Omega$

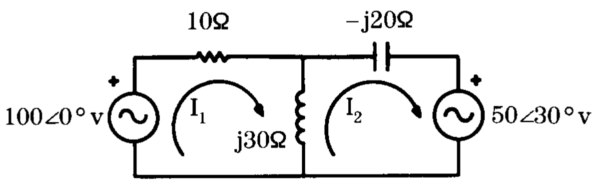
Where:
C = capacitance in Farads
L = inductance in Henries
f = frequency in Hertz

To write a system of simultaneous equations describing the circuit,

- State each capacitive reactance as a negative imaginary number.
- State each inductive reactance as a positive imaginary number.
- Write equations based on the fact that the algebraic sum of voltages around a closed loop is equal to zero.

Example

The following circuit has two current loops.



(continued)

Example (Continued)

The voltage equations for each loop are:

Loop 1: $10I_1 + j30(I_1 - I_2) = 100\angle 0°$
Loop 2: $j30(I_2 - I_1) - j20I_2 = -50\angle 30°$

Regrouping the coefficients of voltage yields:

Loop 1: $I_1(10 + j30) + I_2(-j30) = 100\angle 0°$
Loop 2: $I_1(-j30) + I_2(j10) = -50\angle 30°$

Writing the system of equations in matrix form yields:

$$\begin{bmatrix} (10+j30) & -j30 \\ -j30 & j10 \end{bmatrix} \begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 100\angle 0° \\ -50\angle 30° \end{bmatrix}$$

Find I_1 and I_2.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Set angle units to degrees.	If D is not indicated, press [3rd] [DRG>] until it is.	_
Select polar form.	If PO is not indicated, press [3rd] [RP>] until it is.	_

Example (Continued)

Procedure	Press	Display
Begin entry sequence.	[2nd] [SIMUL]	Equa 2–5?
Specify 2nd order.	2	Complex YN?
Specify complex.	Y	a11=?
Enter the row 1, column 1 coefficient.	[(] 10 [,] 30 [)] [ENTER]	a12=?
Enter the coefficient.	[(] 0 [,] [(-)] 30 [)] [ENTER]	b1=?
Enter the row 1 solution vector coefficient.	100 [ENTER]	a21=?
Enter the coefficient.	[(] 0 [,] [(-)] 30 [)] [ENTER]	a22=?
Enter the coefficient.	[(] 0 [,] 10 [)] [ENTER]	b2=?
Enter the row 2 solution vector coefficient.	[(] [(-)] 50 [2nd] [∠] 30 [)] [ENTER]	Review YN?
Select to review.	Y	a11=(10,30)
Advance through the coefficients.	[ENTER] [ENTER] [ENTER] [ENTER] [ENTER]	a12=(0,−30) b1=(100,0) a21=(0,−30) a22=(0,10) b2=(50∠−150)

(continued)

Example (Continued)

Procedure	Press	Display
Proceed with results.	[SOLVE]	x1=(1.327386977
View the rest of x_1	[→] [→] ... [→]	∠-31.20035601)
View the next solution.	[ENTER]	x2=(2.441627374
View the rest of x_2	[→] [→] ... [→]	∠68.21406544)
Leave the solution set.	[2nd] [EXIT]	_

The currents in the two loops are approximately I_1 = 1.327a at -31.2° phase angle, and I_2 = 2.44 a at 68.2° phase angle.

Chapter 8: Polynomial Roots

The calculator has a built-in feature that finds the roots of a second-, third-, or fourth-order polynomial. The roots may be real or complex. This chapter explains how to calculate polynomial roots with this feature.

Chapter Contents

Coefficient Conventions

A polynomial is the sum of terms in which each term has a coefficient or is a constant term. Each coefficient multiplies a variable raised to a positive integer power. In an x-y plane, the polynomial intersects the x axis at points called the roots.

Terms of a Polynomial

A polynomial for which the calculator is to find the roots must have the correct sequence of terms. The three allowable orders of polynomials are presented here.

Fourth Order
$A_4x^4 + A_3x^3 + A_2x^2 + A_1x + A_0 = 0$

Third Order
$A_3x^3 + A_2x^2 + A_1x + A_0 = 0$

Second Order
$A_2x^2 + A_1x + A_0 = 0$

To sort the terms of a polynomial into the correct sequence, you should:

- Write the highest-order term at the beginning of the polynomial.
- Place the rest of the terms in descending sequence according to the order of the variable in each term.
- Combine terms of equal order into one term.
- Include a zero coefficient for any lower-order terms that are absent from the polynomial.

The polynomial root finder does not allow complex numbers to be used as coefficients.

Altering Certain Non-Polynomials Into Polynomials

You can sometimes transform the variable of a non-polynomial expression to make the expression a polynomial. For example,

$$2b^2 - b^{.5} = 0$$

is not a polynomial. However, you can set $b^{.5}$ equal to x, which makes b^2 equal to x^4. You could enter the fourth-order polynomial

$$2x^4 + 0x^3 + 0x^2 + -1x + 0 = 0$$

to obtain a set of roots. To find the b roots, square each x root.

Solution Set

The order of the polynomial determines the number of roots in the solution set. Some polynomials have distinct roots. Other polynomials have duplicate roots. Certain combinations of positive and negative real coefficients often cause a polynomial to have complex roots.

Solution Procedure for Polynomial Roots

The calculator's built-in feature for obtaining the roots of a polynomial keeps you aware of the meaning of each entry and result. The calculator prompts you for each coefficient, and it labels each root.

Procedure

Follow the procedure below to obtain the roots of a polynomial.

1. Check the settings of the calculator to be sure that the decimal number system is selected.

2. Examine the polynomial to identify its order and coefficients.

3. Press [2nd] [POLY]. The calculator prompts you for the order of the polynomial.

4. Respond with the order of the polynomial, 2, 3, or 4. The calculator prompts you for the first coefficient.

5. Respond with the value of each coefficient. You can enter digits, recall a value, or enter an expression for the value of a coefficient.

   If you enter an expression for the value of a coefficient, it should not use the store and exchange functions, nor should it exceed six pending real values or three pending complex values.

   After you type in a coefficient, press [ENTER].

   If you need to quit during coefficient entry, you can press [2nd] [EXIT] or [2nd] [OFF] and the sequence will stop. You can also leave the polynomial sequence to start a different sequence by pressing [2nd] [VAR], [2nd] [FMLA], or [2nd] [SIMUL].

   Continue with the coefficients until you have entered the last one, A_0. Then the prompt **Review YN?** appears.

Procedure (Continued)

6. To review the coefficients, respond Y. The first coefficient appears. Go to step 7.

   To skip reviewing the coefficients and accept their current values, respond N and go to step 8.

7. When reviewing coefficients, you can advance to other coefficients by pressing [2nd] [NEXT], [2nd] [BACK], or [ENTER]. When you revise the value of a coefficient, first notice whether the existing value has more digits than the new value. You can save time by clearing a long value before typing the digits of a new value. You also may type an expression for the new value. Inserting and deleting are also allowed.

   Then, to accept the revision:

   - And accept all other coefficients, press [SOLVE] and go to step 8.

   - And continue with the next coefficient, press [ENTER].

   Continue reviewing the coefficients until they are satisfactory. Then press [SOLVE] and go to step 8.

   If you advance past the last coefficient, the prompt **Review Y/N?** appears. Go back to step 6.

(continued)

Procedure (Continued)

8. The calculator determines the roots of the polynomial and displays the first one.

   If the root goes past the display, you can scroll to the rest of the value with [←] and [→].

   If you need to use the root in later calculations, you should store it as a variable before leaving the solution set.

   To view other roots, press [2nd] [NEXT], [2nd] [BACK], or [ENTER].

9. Leave the solution set by pressing [2nd] [EXIT] or any key other than those used for viewing results: [←], [→], [ENTER], [2nd] [NEXT], [2nd] [BACK], or [STO].

Application: Roots of a Fourth Order Polynomial

Find the roots of $x^4 + 4x^3 - 19x^2 - 106x - 120$.

Solution

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Begin entry sequence.	[2nd] [POLY]	Order 2–4?
Specify 4th order.	4	A4=?
Enter the coefficient.	1 [ENTER]	A3=?
Enter the coefficient.	4 [ENTER]	A2=?
Enter the coefficient.	[(-)] 19 [ENTER]	A1=?
Enter the coefficient.	[(-)] 106 [ENTER]	A0=?
Enter the coefficient.	[(-)] 120 [ENTER]	Review YN?
Select not to review.	N	x1= -2
View the next root.	[ENTER]	x2= 5
View the next root.	[ENTER]	x3= -3
View the next root.	[ENTER]	x4= -4
Leave the solution set.	[2nd] [EXIT]	_

The roots are -2, 5, -3, and -4.

Application: All Fourth Roots of a Negative Number

You can obtain all the second, third, or fourth roots (including complex) of a negative number by writing an appropriate polynomial and using the calculator's polynomial root finder. For the fourth roots of −81, let $x^4 = -81$. The polynomial is $x^4 + 81 = 0$.

Solution

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Set angle units to degrees.	If D is not indicated, press [3rd] [DRG>] until it is.	_
Select polar form.	If PO is not indicated, press [3rd] [RP>] until it is.	_
Begin entry sequence.	[2nd] [POLY]	Order 2-4?
Specify 4th order.	4	A4=?
Enter the coefficient.	1 [ENTER]	A3=?
Enter the wrong coefficient.	81 [ENTER]	A2=?
Enter the coefficient.	0 [ENTER]	A1=?
Enter the coefficient.	0 [ENTER]	A0=?
Enter the coefficient.	81 [ENTER]	Review YN?
Select to review.	Y	A4=1
Accept the coefficient.	[ENTER]	A3=81
Correct the coefficient.	[CLEAR] 0 [ENTER]	A2=0
Proceed with results.	[SOLVE]	x1= (3∠45)
Store this root in R and view the next root.	[STO] [ALPHA] R [ENTER]	x2= (3∠-45)

Solution (Continued)

Procedure	Press	Display	
View the next root.	[ENTER]	x3=	(3∠135)
View the next root.	[ENTER]	x4=	(3∠-135)
Leave the solution set.	[CLEAR]	_	
Raise the stored root to the fourth power.	[(] [ALPHA] R [yˣ] 4 [)] [2nd] [P▸R] [ENTER]	(-81, -1.782E-11)	

Raising this root to the fourth power obtains the original number, -81. Although the displayed answer is not quite zero in the imaginary part, it is so small that it is insignificant.

Chapter 9: Hexadecimal, Octal, and Binary Calculations

The calculator interprets the number base of each entry individually. This entry feature enables you to perform calculations in the hexadecimal, octal, and binary number bases, or to combine different number bases within a calculation.

Chapter Contents

Designating a Number Base

The number base of a number you enter is determined either by an accompanying symbol (which designates the decimal, hexadecimal, octal, or binary number base), or by the setting for the default number base when no designator is included.

Base Designator Symbols

The third row of the keyboard has the symbols d, h, o, and b. Similar to the alphabetic characters, these are accessed by the [ALPHA] key. However, they have a different purpose.

- ► Alphabetic characters (A through Z) are for spelling variable names and formula names.
- ► The symbols d, h, o, and b are for designating a number base. These are not allowed in variable names or formula names.

To distinguish between a base designator and an alphabetic character, this manual shows the key in angle brackets < > when the symbol is one of the base designators. The syntax for a number with a designated number base is:

*number*d
*number*h
*number*o
*number*b

1. Begin with the number that is to be in the designated number base.
2. Follow it with the d, h, o, or b symbol ([ALPHA] <d>, [ALPHA] <h>, [ALPHA] <o>, or [ALPHA] <b>).

Default Number Base Selection

A number that is entered without a base designator is interpreted in the currently selected default number base. This setting is indicated by HEX, OCT, or BIN (or the absence of these) in the display. If none of these three indicators is visible, the default number base is decimal. To advance through the number bases, press [3rd] [BASE>].

The number base that is appropriate depends on whether a function you need is available in the number base, how you would like results to appear, and whether most of the entries are in the same number base.

Appearance of Results

For results that are hexadecimal, octal, or binary numbers, a designator accompanies the number. No designator accompanies a decimal number base result.

Nondecimal Number Base Considerations

The nondecimal number bases operate for integers only. A decimal point is invalid in bases other than the decimal number base. The results of calculations such as division that often would have a noninteger result are rounded to the nearest integer.

Some of the more specialized calculations require decimal as the default number base:

- Polynomial Roots
- Simultaneous Equations
- Integration
- Statistics

You should observe the setting of the default number base before beginning these activities. The calculator does not revert to the decimal number base when you turn it off.

Digits in an entry should be only among those that are valid for the number base of the entry.

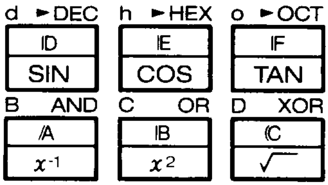
Binary	0, 1
Octal	0, 1, 2, 3, 4, 5, 6, 7
Decimal	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Hexadecimal	0, 1, 2, 3, 4, 5, 6, 7, 8, 9, **A**, **B**, **C**, **D**, **E**, **F**

Alpha characters A, B, C, D, E, and F cannot be substituted for hexadecimal **A**, **B**, **C**, **D**, **E**, and **F**.

Scientific notation extends the calculator's range past ten digits only for decimal values. There is no similar notation for hexadecimal, octal, and binary values. Therefore, nondecimal values are limited to ten digits.

Keyboard Changes for the Hexadecimal Setting

The calculator reassigns six first function keys when the default number base is set to hexadecimal. The keys do not access the first functions that are marked:



Instead, the hexadecimal digits **A** through **F** occupy the first functions, while still being accessible as second functions.

By reassigning these six keys, the hexadecimal setting simplifies the entry of hexadecimal numbers and suppresses six functions that do not apply in hexadecimal.

While you are entering an expression and need one of these six functions, you can change number bases to restore the functions. Then you can change back to hexadecimal and continue a hexadecimal entry.

Number System Notations

Where more than one number system is involved, this manual uses the following notations to denote decimal, hexadecimal, octal, and binary numbers.

10d 10h 10o 10b

Converting to a Desired Number Base

Because the calculator handles each number according to its designated number base, you do not need to convert numbers before using them in a calculation. However, for the task of converting a number to a desired number base, four conversions are provided.

Base Conversions

You can convert a number to any of the four number bases. The syntax for a number base conversion is:

number ▸DEC
number ▸HEX
number ▸OCT
number ▸BIN

1. Begin with the number to be converted. The calculator interprets the number according to its base designator or from the default number base setting.
2. Follow it with the ▸DEC, ▸HEX, ▸OCT, or ▸BIN function ([3rd] [▸DEC], [3rd] [▸HEX], [3rd] [▸OCT], or [3rd] [▸BIN]).

To execute an entry, press [ENTER].

When executed, the conversion determines the value in the new base but does not change the default number base setting. A nondecimal result includes the appropriate number base designator: h, o, or b.

Note: When the calculator is set to a nondecimal default number base and you convert to decimal, you should ignore the number base indicator and know from the conversion you entered that the result is a decimal number. A decimal result appears with no designator, which gives it a different appearance than results in the other number bases.

Example

Convert 1001b to a decimal number.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Enter the expression.	1001 [ALPHA] 〈b〉 [3rd] [▸DEC]	1001b ▸DEC_
Evaluate the expression.	[ENTER]	9

Complement Functions

The two's complement results in the negative of an integer entry. Negative nondecimal numbers have no minus sign; the bits of the number convey whether it is positive or negative. The one's complement is called "not."

The Two's Complement Function

The two's complement function subtracts one from a number and replaces each bit with the value it is not. After the subtraction, each 1 becomes a 0 and each 0 becomes a 1.

The syntax for a two's complement calculation is:

2's *number*

1. Begin with the 2's function ([3rd] [2's]).
2. Follow it with the number or expression whose two's complement is being calculated.

To execute an entry, press [ENTER].

If you calculate the two's complement of a decimal number, it is rounded to an integer and negated.

The Not Function

The not function (also called the one's complement) simply replaces each bit with the value it is not. Each 1 becomes a 0 and each 0 becomes a 1.

The syntax for a one's complement calculation is:

not *number*

1. Begin with the not function ([3rd] [NOT]).
2. Follow it with the number or expression whose one's complement is being calculated.

To execute an entry, press [ENTER].

If you calculate the one's complement of a decimal number, it is rounded to an integer, increased by 1, and negated.

Examples

Find the two's complement of 111100000b and the one's complement of 100100100b.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select binary.	If BIN is not indicated, press [3rd] [BASE>] until BIN appears.	_
Calculate 2's.	[3rd] [2's] 111100000 [ENTER]	1000100000b
Calculate "not".	[3rd] [NOT] 100100100 [ENTER]	1011011011b

Positive and Negative Nondecimal Numbers

Nondecimal numbers are grouped into sets of positive numbers and negative numbers. To distinguish the two sets, you should be familiar with the purpose of some of the bits.

Positive Binary Numbers

In binary, the leftmost bit among 10 digits is reserved for the sign of the number (0 for positive, 1 for negative). When a binary number appears with nine or fewer digits, it is positive, and the bits are interpreted according to the traditional rules of number systems: the least significant bit is the 2^0 place, the next bit is the 2^1 place, up to the ninth bit from the right being the 2^8 place.

Negative Binary Numbers

When a binary number appears with ten digits, it is negative, and the bits no longer follow the traditional rules of number systems. Instead, the sequence of numbers beginning with 1000000001b corresponds to the sequence of decimal numbers beginning with −511 and ascending to −1, with −1 being equal to 1111111111b.

Positive Octal and Hexadecimal Numbers

In octal or hexadecimal, the leftmost among 10 digits contains the sign of the number (3 or below for positive octal, 4 or above for negative octal, 7 or below for positive hexadecimal, 8 or above for negative hexadecimal). When an octal or hexadecimal number appears with nine or fewer digits, it is positive, and the digits are interpreted according to the traditional rules of number systems. In octal or hexadecimal, the least significant digit is the 8^0 or 16^0 place. The next digit is the 8^1 or 16^1 place, up to the ninth digit from the right being the 8^8 or 16^8 place. When an octal or hexadecimal number appears with ten digits, the first digit must be 3 or less in octal or 7 or less in hexadecimal for the number to be positive.

Negative Octal and Hexadecimal Numbers

When an octal or hexadecimal number appears with ten digits and begins with 4 or higher for octal or 8 or higher for hexadecimal, it is negative, and the digits no longer follow the traditional rules of number systems. Instead, the numbers correspond to negative decimal numbers as listed here.

Decimal	−549755813887d	−536870911d	−1d
Octal		4000000001o	7777777777o
Hexadecimal	8000000001h		FFFFFFFFFFh

Arithmetic in One Number Base

When a calculation is all in the same number base, you do not need to include the designator for that number base with each entry if you select that base as the default. By setting the default number base to the one for your calculation, you simplify the entry sequence.

Example

Calculate 3**A**h – 3**F**h while the decimal number base is selected. Convert the result to hexadecimal. Repeat the problem with the hexadecimal number base selected.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select decimal.	If HEX, OCT, or BIN is indicated, press [3rd] [BASE>] until none of these is visible.	_
Enter the problem.	3 [2nd] [**A**] [ALPHA] 〈h〉 [–] 3 [2nd] [**F**] [ALPHA] 〈h〉 [ENTER]	–5
Convert to hexadecimal.	[3rd] [►HEX] [ENTER]	FFFFFFFFFBh
Select hexadecimal.	[3rd] [BASE>]	FFFFFFFFFBh
Repeat the problem.	3**A** [–] 3**F** [ENTER]	FFFFFFFFFBh

Arithmetic in Mixed Bases

You can perform arithmetic with a combination of decimal, hexadecimal, octal, and binary numbers. Just include the appropriate number base designator with each entry.

Example 1

Calculate the hexadecimal result of 45h + 25d. Convert the result to decimal.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select hexadecimal.	If HEX is not indicated, press [3rd] [BASE>] until HEX appears.	_
Enter the problem.	45 [+] 25 [ALPHA] <d> [ENTER]	5Eh
Convert the result.	[3rd] [►DEC] [ENTER]	94

Example 2

Calculate the hexadecimal result of 16d × 1000h.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select hexadecimal.	If HEX is not indicated, press [3rd] [BASE>] until HEX appears.	_
Enter the problem.	16 [ALPHA] <d> [×] 1000 [ENTER]	10000h

Example 3

Calculate the octal result of 64d ÷ 3d. Also determine the decimal result of 64d ÷ 3d.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select octal.	If OCT is not indicated, press [3rd] [BASE>] until OCT appears.	_
Enter the problem.	64 [ALPHA] <d> [÷] 3 [ALPHA] <d> [ENTER]	25o
Select decimal and convert to decimal.	[3rd] [BASE>] [3rd] [BASE>] [3rd] [▸DEC] [ENTER]	21
Enter the problem.	64 [÷] 3 [ENTER]	21.33333333

Notice that the result is rounded to an integer when the decimal number base is not selected.

Logic Operations

A logic operation combines two numbers, bit by bit. Each logic operation has a set of rules that determines whether a corresponding bit in the answer is a 1 or a 0. The logic operations include and, or, and xor (exclusive or). Logic operations can also work with [STO] to perform memory logic.

Logic Functions

The [3rd] [AND], [3rd] [OR], and [3rd] [XOR] key sequences place the symbol for their corresponding function in the display. You enter each of these functions between the two numbers or expressions it is combining.

and—The bit in a specific position of the result is a 1 only if the corresponding anded bits are both 1.

or—The bit in a specific position of the result is a 1 only if a 1 is among the corresponding ored bits.

xor—The bit in a specific position of the result is a 1 only if the corresponding exclusive ored bits differ.

For a discussion of the algebraic hierarchy and how logic functions are ranked, refer to Chapter 2.

By using "not" along with these logic operations, you can calculate other logic operations.

nand— not of two anded numbers
nor—not of two ored numbers
xnor—not of two exclusive ored numbers

Logic Example

Calculate the binary result of 11111b and (10011b nor 10100b).

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select binary.	If BIN is not indicated, press [3rd] [BASE>] until BIN appears.	_
Calculate the result.	11111 [3rd] [AND] [3rd] [NOT] [(] 10011 [3rd] [OR] 10100 [)] [ENTER]	1000b

Memory Logic Example

Store 1Fh and logical and 23o to it in memory. Also logical or 10100b to memory.

Procedure	Press	Display
Clear the entry line.	[CLEAR]	_
Select hexadecimal.	If HEX is not indicated, press [3rd] [BASE>] until HEX appears.	_
Perform the memory logic.	1F [STO] [ALPHA] Q [ENTER] 23 [ALPHA] ‹o› [STO] [3rd] [AND] [ALPHA] Q [ENTER] 10100 [ALPHA] ‹b› [STO] [3rd] [OR] [ALPHA] Q [ENTER]	10100b
Show the stored result.	[RCL] [ALPHA] Q [ENTER] [ENTER]	17h

Chapter 10: Statistics

In situations in which you have observed some trait among the members of a population, you can take a set of measurements and analyze the data set using statistical techniques. This chapter discusses the keys that perform various statistics functions, including entering statistical data and obtaining statistical results.

Chapter Contents

The Statistics Procedure

You use a three-step procedure to solve a statistics problem: tabulate the data, enter the data, and view the results.

Step 1: Tabulate the Data

Gathering your data into a table is the first step in solving a statistics problem. The way you tabulate your data depends on the situation you are observing.

- For one-variable data, the data set has one number per measurement: x (also called unpaired data).
- For two-variable data, the data set has two numbers per measurement: x,y (also called paired data).

It may be appropriate to tabulate data as an expression instead of the digits of a value. For example, when you have measured a length that is 4′5″, you can use the expression 4 + 5 ÷ 12 instead of 4.416666667.

When equal measurements are in the data set, you can group them as one value with repetitions (called "frequency").

Tabulating the data helps you to enter it without repeating an entry or leaving one out.

Step 2:
Enter the Data

Before starting a statistics problem with a new data set, clear the statistics registers. Begin by pressing [2nd] [CS]. The display shows **Clr YN?**. You can cancel by responding N or proceed with clearing by responding Y.

Enter the data as unpaired (one-variable) or paired (two-variable) entries. You cannot mix paired and unpaired data.

You can remove data points. However, if you remove all the data points, the message **Cleared** appears. After pressing [CLEAR], you can enter a new data set.

After you enter or remove a data point, the display shows the number of points currently in the data set. To allow your data set to have an almost unlimited number of points, the calculator does not store the numbers exactly as you enter them. Instead, the calculator combines each entry into six registers that represent the data set. Another half register is used to keep track of the data set.

It is possible for a data set containing extremely large numbers to exceed the range of the calculator during data entry. If this happens, the statistics registers are cleared and the message **Cleared** appears. After pressing [CLEAR], you can adjust the magnitude of the data and reenter the data set.

Step 3:
View the Results

You can view results at any time during the entry or modification of a data set. The results pertain only to the data points that are currently entered. Because each change you make to the data set changes the results, you normally enter all data before viewing the results.

Entering and Removing Data

The way you enter data depends on the type of data set you are analyzing. A data set can consist of unpaired values, paired values, or paired values at incremented points.

Entering Unpaired Data

To enter a data set in which the values are unpaired:

1. Type the number or expression that is the data point.
2. Sum the point into the statistics registers, accounting for how many times it occurs.
   - If the data point occurs once, press [Σ+].
   - If the data point occurs just a few times, you can press [Σ+] once for each occurrence.
   - If the data point occurs many times, press [3rd] [FRQ] followed by a number from 1 to 999 to specify the number of occurrences. Then press [Σ+].
3. If you wish to remove the data point you just entered, press [INV] [Σ+] directly after it is entered. The data point is deleted and the display shows the number of points currently entered.
4. Repeat steps 1 and 2 for each remaining point in the data set.
5. If you realize that a data point you entered earlier should not be part of the data set, you should:
   - Type the same number or expression as you did earlier for the undesired data point. If applicable, include the frequency.
   - Press [INV] [Σ+]. The data point is deleted and the display shows the number of points currently entered.

Entering Ordinary Paired Data

To enter a data set in which the values are paired, but not necessarily spaced at regular intervals:

1. Type the number or expression for the x value, press [,], and type the number or expression for the corresponding y value.

2. Sum the point into the statistics registers, accounting for how many times it occurs.

   - If the data point occurs once, press [Σ+].

   - If the data point occurs just a few times, you can press [Σ+] once for each occurrence.

   - If the data point occurs many times, press [3rd] [FRQ] followed by a number from 1 to 999 to specify the number of occurrences. Then press [Σ+].

3. If you wish to remove the data point you just entered, press [INV] [Σ+] directly after it is entered. The display shows the number of points currently entered.

4. Repeat steps 1 and 2 for each remaining point in the data set.

5. If you realize that a data point you entered earlier should not be part of the data set, you should:

   - Type the same pair of numbers or expressions as you did earlier for the undesired data point. If applicable, include the frequency.

   - Press [INV] [Σ+]. The display shows the number of points currently entered.

Entering Trend Line Data

A trend line is observed at incremented points (usually intervals of time). Each x measurement is incremented by 1 and the corresponding y measurement is observed. To enter trend line data:

1. Type the number or expression for the x value, press [,], and type the number or expression for the corresponding y value.

2. Press [Σ+].

3. Press [,] (the incremented x is retrieved automatically) and type the number or expression for the next y value.

4. Press [Σ+].

5. If you wish to remove the data point you just entered, press [INV] [Σ+] directly after it is entered. The calculator reduces x to its previous value.

6. Repeat steps 3 and 4 for each remaining point in the data set.

7. If you realize that a data point you already entered should not be part of the data set, you should:

   - Type the x value, [,], and same number or expression for y as you did earlier for the undesired data point.

   - Press [INV] [Σ+]. The display shows the number of points currently entered.

Statistics Results

The calculator offers a variety of commonly needed statistics results. If you need a result for later calculations, especially a grouped intermediate value, you can store it in a variable.

One-Variable Statistics Results

A one-variable data set has the following results:

Result	Key Sequence
mean of x	2nd [$\bar{x}$]
sample standard deviation of x	2nd [σxn-1]
population standard deviation of x	2nd [σxn]
number of points in the data set	3rd [n]
Grouped intermediate values: ► sum of x entries ► sum of squares of x entries	3rd [Σxy]

Advance through the grouped values with 2nd [NEXT], 2nd [BACK], or ENTER.

Two-Variable Statistics Results

A two-variable data set has the following results:

Result	Key Sequence
mean of x	2nd [$\bar{x}$]
mean of y	2nd [$\bar{y}$]
sample standard deviation of x	2nd [σxn-1]
population standard deviation of x	2nd [σxn]
sample standard deviation of y	2nd [σyn-1]
population standard deviation of y	2nd [σyn]
number of points in the data set	3rd [n]
slope of regression line	3rd [SLP]
y-intercept of regression line	3rd [ITC]
correlation coefficient	3rd [COR]
x for a trial y	3rd [x′] y
y for a trial x	3rd [y′] x
Grouped intermediate values: ► sum of x entries ► sum of y entries ► sum of squares of x entries ► sum of squares of y entries ► sum of products of x and y	3rd [Σxy]

Advance through the grouped values with 2nd [NEXT], 2nd [BACK], or ENTER.

One-Variable Application: Analyzing a Population

By measuring every member of a population, you can be certain of the analysis. Population statistics are appropriate for such a data set.

Example

A class of 12 students made the following scores on a test. Calculate the mean and the standard deviation.

96 81 85 76 86 57 98 75 78 100 72 70

Because you are entering scores for all of the class, the "n weighted" (population) standard deviation is appropriate.

Procedure	Press	Display
Clear the statistics registers.	[2nd] [CS] Y	Cleared
Enter the test scores.	96 [Σ+] 81 [Σ+] 85 [Σ+] 76 [Σ+] 86 [Σ+] 57 [Σ+] 98 [Σ+] 75 [Σ+] 78 [Σ+] 100 [Σ+] 72 [Σ+] 70 [Σ+]	n= 12
Enter an extra value.	66 [Σ+]	n= 13
Remove the extra value.	[INV] [Σ+]	n= 12
Calculate the mean.	[2nd] [$\bar{x}$] [ENTER]	81.16666667
Calculate the population standard deviation.	[2nd] [σxn] [ENTER]	12.12321006

One-Variable Application: Analyzing a Sample

Instead of testing every element in a population, you may decide to test just a sample of the elements. If you select the sample at random, you can assume that it represents the entire population. Then you can describe the population by calculating mean, variance, and "n – 1 weighted" standard deviation of the random sample.

Example

You want to find the average height for a class of 99 students, but you cannot measure every student.

Randomly select a sample of eight students, and measure their heights. The height measurements (in inches) are listed below in ascending order.

63 66 69 69 71 72 74 76

Show Σx and Σx^2 and calculate the sample mean and standard deviation (σ_{n-1}).

Procedure	Press	Display
Clear the statistics registers.	[2nd] [CS] Y	Cleared
Enter the data values.	63 [Σ+] 66 [Σ+] 69 [Σ+] [Σ+] 71 [Σ+] 72 [Σ+] 74 [Σ+] 76 [Σ+]	n= 8
Show the data sum.	[3rd] [Σxy]	Σx= 560
Show the sum of squares.	[2nd] [NEXT]	Σx^2= 39324
Calculate the mean.	[2nd] [x̄] [ENTER]	70
Calculate the standard deviation.	[2nd] [σxn-1] [ENTER]	4.208834246

For the sample of eight measurements, the average height is 70 inches and the standard deviation is about 4.2 inches.

Two-Variable Application: Linear Regression

With linear regression, you can derive a relationship between two variables based on observed data. You can apply the relationship to an unobserved point and estimate its behavior. This example relates an area's skyline to its population. Based on known areas, you predict the population for a given number of buildings over 12 stories.

Example

A survey of metropolitan areas has determined approximate numbers of buildings over 12 stories in each area as follows.

Area population (thousands)	150	250	500	500	1000
Tall buildings	4	10	20	30	70
Number of metropolitan areas	50	30	6	7	4

Perform a linear regression analysis to predict the population of an area that has 16 buildings over 12 stories. Determine the correlation coefficient of the data values and the slope and intercept of the line.

Example—Part A

First, tabulate the data in terms of x and y. Then, enter the x and y values into the statistics registers to predict the x value if the y value is 16.

x	y	Frq
150	4	50
250	10	30
500	20	6
500	30	7
1000	70	4

(continued)

Example— Part A (Continued)

Procedure	Press	Display
Clear the statistics registers.	[2nd] [CS] Y	Cleared
Enter the data set.	150 [,] 4 [3rd] [FRQ] 50 [Σ+] 250 [,] 10 [3rd] [FRQ] 30 [Σ+] 500 [,] 20 [3rd] [FRQ] 6 [Σ+] 500 [,] 30 [3rd] [FRQ] 7 [Σ+] 1000 [,] 70 [Σ+] [Σ+] [Σ+] [Σ+]	n= 97
Predict the x value for y = 16.	[3rd] [x'] 16 [ENTER]	325.4741465

With 16 buildings over 12 stories, a metropolitan area should have about 325 thousand people.

Note: Do not erase the data from the statistics registers. The data values are used in the next part of the example.

In parts B and C of the example, you view the statistics result that indicates how accurately the calculated line represents the data and also the results that describe the calculated line.

Example— Part B

View the intermediate results and determine the correlation coefficient of the data set from Part A.

Procedure	Press	Display
Show intermediate values.	[3rd] [Σxy]	Σx= 25500
	[ENTER]	Σy= 1110
	[ENTER]	Σx^2= 10250000
	[ENTER]	Σy^2= 32100
	[ENTER]	Σxy= 550000
View the correlation coefficient.	[3rd] [COR]	
	[ENTER]	0.984414864

Because this value is close to 1, the data values have a strong positive relationship.

Note: Do not erase the data from the statistics registers. The data is used in the next part of the example.

Example— Part C

Determine the equation that best represents the data, y = x × (slope) + (intercept).

Procedure	Press	Display
Display the slope.	[3rd] [SLP]	
	[ENTER]	0.072805233
Display the intercept.	[3rd] [ITC]	
	[ENTER]	-7.69622093

The line's equation is:
y = x × (0.072805233) + (−7.69622093).

Later, if you have cleared the statistics registers and want to predict y for any given x value, you can use this equation without re-entering all the data.

Two-Variable Application: Trend Line

You can also apply linear regression to analyze data that is in the form of yearly figures. This type of linear regression is referred to as "trend line analysis" and is helpful in predicting what will happen in subsequent years.

Example

A stock has reported the following earnings per share from 1982 through 1986.

$1.52 $1.35 $1.53 $2.17 $3.60

Use trend line analysis to predict the earnings per share for the next three years and to predict the year in which you could expect the earnings per share to reach $6.50.

Example—Part A

First tabulate the data in terms of x and y.

x	y
1982	$1.52
1983	$1.35
1984	$1.53
1985	$2.17
1986	$3.60

To enter this trend line data:

1. Type the first x value (1982) and press [,].
2. Type the first y value (1.52) and press [Σ+].
3. For each successive point, press [,] followed by the y value and [Σ+].

(continued)

Example—Part A (Continued)

Procedure	Press	Display
Clear the statistics registers.	[2nd] [CS] Y	Cleared
Fix the decimal point at two places.	[2nd] [FIX] 2	_
Enter the first pair of data values.	1982 [,] 1.52 [Σ+]	n= 1.00
Enter the remaining y data.	[,] 1.35 [Σ+] [,] 1.53 [Σ+] [,] 2.17 [Σ+] [,] 3.6 [Σ+]	n= 5.00
Project 1987 earnings.	[3rd] [y′] 1987 [ENTER]	3.53
Project 1988 earnings.	[3rd] [y′] 1988 [ENTER]	4.03
Project 1989 earnings.	[3rd] [y′] 1989 [ENTER]	4.52
Find the year that projected earnings will be $6.50.	[3rd] [x′] 6.50 [ENTER]	1992.97

According to the trend calculated from the known data, the earnings predicted for 1987 are $3.53, the earnings predicted for 1988 are $4.03, and the earnings predicted for 1989 are $4.52. The predicted earnings will reach $6.50 in 1993 (the first full year after 1992.97).

Note: Do not clear the statistics registers. The data values are used in the next part of the example.

Example— Part B

Using the data values entered in Part A, determine the relationship among the pairs of data values by calculating the correlation coefficient.

Procedure	Press	Display
Calculate the correlation coefficient.	[3rd] [COR] [ENTER]	0.85

Because the sampling is at regular intervals, x is not a random normal variable. With a partly nonrandom data set, the correlation coefficient needs modification to gauge data linearity accurately. You square the correlation coefficient to determine the "coefficient of determination." In this example it is $.85^2 = .72$.

Statistical Validity

Linear regression is best suited to making predictions that are within the range of measured data. However, with acceptable uncertainty, trend line analysis techniques are routinely used to make predictions or estimations about the future.

Mathematical Definitions of Statistical Quantities

The following equations describe how the calculator obtains its statistical results.

Data Mean

The mean is calculated according to these equations:

$$\bar{x} = \frac{\sum_{i=1}^{n} x_i}{n} \qquad \bar{y} = \frac{\sum_{i=1}^{n} y_i}{n}$$

Population Standard Deviation

"n weighted" (or "population") standard deviation is calculated according to these equations:

$$\sigma_{xn} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n}} \qquad \sigma_{yn} = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n}}$$

Sample Standard Deviation

"n−1 weighted" (or "sample") standard deviation is calculated according to these equations:

$$\sigma_{xn-1} = \sqrt{\frac{\sum_{i=1}^{n} (x_i - \bar{x})^2}{n-1}} \qquad \sigma_{yn-1} = \sqrt{\frac{\sum_{i=1}^{n} (y_i - \bar{y})^2}{n-1}}$$

Variance

Squaring σ_{xn}, σ_{xn-1}, σ_{yn}, or σ_{yn-1} results in the corresponding variance.

Predicted Value

The regression line can help to predict values. y′ determines a y value for a desired x value.

$$y = x \times \text{slope} + \text{intercept}$$

x′ determines an x value for a desired y value.

$$x = (y - \text{intercept}) \div \text{slope}$$

Appendix A: Reference Information

This appendix provides reference information that may be helpful as you become more knowledgeable about your TI-68 scientific calculator.

Appendix Contents

Syntax of Functions

Functions can require one of three main syntax forms. These three forms, along with syntax reminders for specific functions, combined syntax forms, and statistics syntax forms are described in this section.

Main Syntax Forms

The three main syntax forms, along with the functions that use each form, are listed below.

number function

>BIN	DMS>DD	G>R	>OCT	-1
°C>°F	D>R	>HEX	P>R	2
cm>in	Exc *VAR*	in>cm	R>D	!
DD>DMS	°F>°C	kg>lb	R>G	%
>DEC	gal>l	lb>kg	R>P	
D>G	G>D	l>gal	Sto*VAR*	

function *number*

abs	frc	real	$sinh^{-1}$	y′
cos	imag	rnd	tan	2's
cos^{-1}	int	sig	tan^{-1}	10^
cosh	ln	sin	tanh	−
$cosh^{-1}$	log	sin^{-1}	$tanh^{-1}$	√
e^	not	sinh	x′	

number function *number*

and	or	y^x	×
nCr	$^x\sqrt{}$	+	÷
nPr	xor	−	Δ%

Syntax Reminders For Specific Functions

Function	Syntax
powers (universal)	*number* [y^x] *power*
roots (universal)	*root* [2nd] [$\sqrt[x]{}$] *number*
permutations	*set* [3rd] [nPr] *subset*
combinations	*set* [3rd] [nCr] *subset*
delta percent	*number* [2nd] [Δ%] *compared to*
rectangular complex number	[(] *x* [,] *y* [)]
polar complex number	[(] *magnitude* [2nd] [∠] *angle* [)]
deg/min/sec number	*deg* [DMS] *min* [DMS] *sec* [DMS]

Combined Syntax Forms

Function	Syntax
% add-on	*starting amount* [+] *add-on* [2nd] [%]
% discount	*starting amount* [−] *discount* [2nd] [%]
Percentage	*starting amount* [×] *percentage* [2nd] [%]
Percent ratio	*compared number* [÷] *starting amount* [2nd] [%]
Memory +	*added number* [STO] [+] *variable name*
Memory −	*subtracted number* [STO] [−] *variable name*
Memory ×	*multiplying number* [STO] [×] *variable name*
Memory ÷	*dividing number* [STO] [÷] *variable name*
Memory y^x	*power* [STO] [y^x] *variable name*
Memory $\sqrt[x]{\ }$	*number* [STO] [2nd] [$\sqrt[x]{\ }$] *variable name*
Memory Δ%	*compared to* [STO] [2nd] [Δ%] *variable name*
Memory and	*number* [STO] [3rd] [AND] *variable name*
Memory or	*number* [STO] [3rd] [OR] *variable name*
Memory xor	*number* [STO] [3rd] [XOR] *variable name*
Nand	[3rd] [NOT] [(] *number* [3rd] [AND] *number* [)]
Nor	[3rd] [NOT] [(] *number* [3rd] [OR] *number* [)]
Xnor	[3rd] [NOT] [(] *number* [3rd] [XOR] *number* [)]

Statistics Syntax Forms

Function	Syntax
one-variable entry	*number* [Σ+]
one-variable entry with frequency	*number* [3rd] [FRQ] *nnn* [Σ+]
one-variable deletion	*number* [INV] [Σ+]
one-variable deletion with frequency	*number* [3rd] [FRQ] *nnn* [INV] [Σ+]
two-variable entry	*x* [,] *y* [Σ+]
two-variable entry with frequency	*x* [,] *y* [3rd] [FRQ] *nnn* [Σ+]
two-variable deletion	*x* [,] *y* [INV] [Σ+]
two-variable deletion with frequency	*x* [,] *y* [3rd] [FRQ] *nnn* [INV] [Σ+]
x for a trial y	[3rd] [x'] *y*
y for a trial x	[3rd] [y'] *x*

Error Conditions

When an error condition occurs, "Error" appears in the display. If you respond by pressing [CLEAR], the error condition is cleared without identifying the error. If you respond by pressing [2nd] [EQU], the calculator usually can show where the error is in your expression.

Causes of Error Conditions

An error condition occurs if you attempt to:

- Calculate a result (including those of memory operations) outside the range of the currently selected number base.

Decimal:	$-9.999999999999 \times 10^{99}$ to -1×10^{-99}, 0 to $9.999999999999 \times 10^{99}$
Hexadecimal:	8000000001 to FFFFFFFFFF, 0 to 7FFFFFFFFF
Octal:	4000000001 to 7777777777, 0 to 3777777777
Binary:	1000000001 to 1111111111, 0 to 111111111

- Divide a number by zero.
- Calculate a logarithm or reciprocal of zero.
- Calculate zero to the 0th power or root, or to a negative power or root.
- Calculate percent change when the second value is zero.
- Calculate the tangent of 90° or 270°, 100 or 300 grads, or their rotational multiples such as 450°.
- Calculate permutations near the peak ($r = n - 1$) for a set size n when n exceeds 69, or when n or r is not a positive integer. The interval near the peak that exceeds the calculator's range expands as n increases above 69.
- Calculate combinations near the peak ($r = n/2$) for a set size n when n exceeds 337, or when n or r is not a positive integer. The interval near the peak that exceeds the calculator's range expands as n increases above 337.

Causes of Error Conditions (Continued)

- Generate more than 24 pending operations, more than eight pending values, or more than 16 consecutive open parentheses. In certain activities the maximum number of pending values reduces to six real or three complex.

- Follow [RCL], [3rd] [EXC], or [STO] *operation* with something other than a defined variable name, or enter an expression containing an undefined variable name.

- Use a real number as the input for polar/rectangular conversions, real part, or imaginary part functions.

- Use a complex number as the input for delta percent, percent, factorial, permutations, combinations, signum, integer portion, fractional portion, angle conversions, deg/min/sec conversions, metric conversions, base conversions, logic functions, polynomial root coefficients, integration, or statistics.

- Begin the polynomial roots, simultaneous equations, or statistics activities with a number base other than decimal selected; or switch out of the decimal number base while these are in progress.

- Enter an expression that includes an inappropriate item for the circumstances, such as a minus sign or decimal in a binary number, or dX in a polynomial coefficient.

- Execute expressions with invalid syntax. (See "Revising an Expression" in Chapter 2 for a list of possible syntax errors.)

- Calculate a function using a value outside the valid input ranges listed for that function. (See "Function Ranges" later in this appendix.)

Statistical Error Conditions

The error conditions listed in this section occur only when working with a statistics data set. These errors occur when you attempt to do the following.

- Enter a one-variable data point when a two-variable data set is already entered.
- Enter a two-variable data point when a one-variable data set is already entered.
- Enter a frequency that has a leading zero.
- Calculate a statistics result when there is no entered statistics data set.
- Calculate sample standard deviation, slope, intercept, correlation, x′, or y′ with just one data point entered.
- Calculate slope, intercept, correlation, x′, or y′ of a data set that consists of repeat occurrences of all the same point, of a line that parallels the y-axis, or when one-variable statistics are selected.
- Calculate the correlation or x′ of a line that parallels the x-axis (horizontal line).

Function Ranges

An error results if you perform a calculation outside the range of certain functions. The following tables give ranges of inputs for certain functions, and ranges of results for inverse trigonometric functions.

Function Input Ranges

Function	**Real Inputs for Real Results**	**Real Inputs for Complex Results**
$\sin^{-1}x$, $\cos^{-1}x$	$\|x\| \leqslant 1$	$-10^{64}<x<-1$ or $1<x<10^{64}$
sinh x, cosh x	$\|x\| <230.95165648$	none
$\cosh^{-1}x$	$1 \leqslant x<10^{100}$	$-10^{64}<x<1$
$\tanh^{-1}x$	$\|x\| <1$	range of the calculator except $\|x\| \leqslant 1$
sin x, cos x, $\tan^{-1}x$, $\sinh^{-1}x$, tanh x, 1/x	range of the calculator (0 invalid for 1/x)	none
ln x, log x, $\sqrt{x}$	positive range of the calculator (0 invalid for logs)	negative range of the calculator
e^x	negative range of the calculator and $x<230.2585092994$	none
10^x	negative range of the calculator and $x < 100$	none
x!	$0 \leqslant x \leqslant 69$ where x is an integer	not defined for complex
universal powers of negative numbers	power is an integer, or is the reciprocal of an odd number	power has magnitude greater than 1 but is not an integer, or is less than 1 but not the reciprocal of an odd number
universal roots of negative numbers	root is an odd number	root has magnitude greater than 1 but is not odd, or is less than 1 but is not the reciprocal of an integer

Inverse Trigonometric Function Ranges

Function	Range of Resulting Angle
arcsin x, arccos x, arctan x	0 to 90°, $\pi \div 2$ radians, or 100G
arcsin −x, arctan −x	0 to −90°, $-\pi \div 2$ radians, or −100G
arccos −x	90° to 180°, $\pi \div 2$ to π radians, or 100G to 200G
Conversion to polar	Positive radius at $-180° < x \leqslant 180°$, $-\pi < x \leqslant \pi$, $-200G < x \leqslant 200G$

Appendix B: Service and Warranty Information

This appenidix describes routines that may help yiou correct any problems in using your TI-68 scientific calculator, as well as the service and warranty provided by Texas Instruments.

Contents

Battery Information

The TI-68 uses a lithium manganese battery for about 1500 hours of operation. You must replace the old battery with Union Carbide (Eveready) CR2032, Duracell DL2032, or the equivalent.

Knowing When to Replace the Battery

As a battery runs down, the display begins to dim. When you find it difficult to read the display under normal viewing conditions, the remaining battery life may be only about one week.

Effects of Replacing the Battery

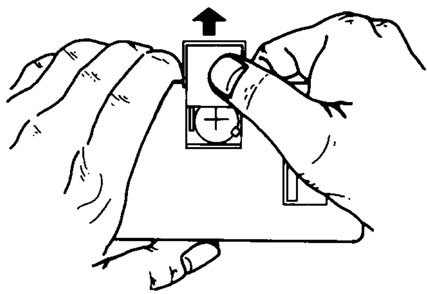
The calculator cannot hold data in its memory when the battery is removed or becomes discharged. Replacing the battery has the same effects as pressing [3rd] [RESET] Y Y Y.

Replacing the Battery

To replace the battery, follow these steps:

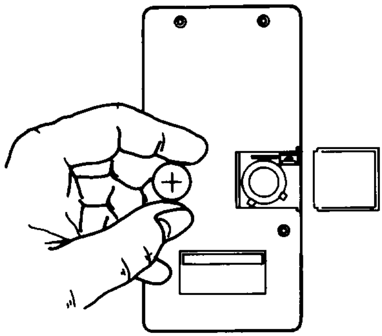
1. Turn the calculator off and turn it over so that the back is facing you.

2. Placing your thumb on the battery cover, press and slide until the cover slides off the back of the calculator.

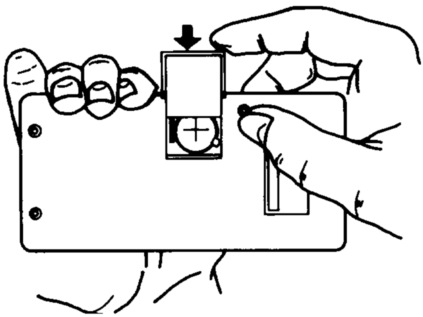


Replacing the Battery (Continued)

3. Remove the discharged battery and install a new one as shown. Be sure that the + symbol is facing up (toward the back of the calculator).



4. Insert the cover into the grooves, pressing gently on the battery, and slide the cover back into place.



The display shows **Mem cleared**, and the calculator is ready to be used.

Caution: Dispose of an old battery properly. Do not incinerate a battery or leave it where a child can find it.

In Case of Difficulty

If you have difficulty operating the calculator, you may be able to correct the problem without returning the calculator for service. The following table lists several problems and their possible solutions. If these solutions do not correct the problem, refer to "Service Information" on page B-6.

Possible Solutions

Difficulty	Solution
The calculator displays results that seem incorrect.	Look for a number base designator that accompanies nondecimal results, or check the number base indicator. Try scrolling to part of the number that may be past the display, especially in a complex result. Also try removing any fixed decimal setting.
Trig functions and polar/rectangular conversions do not give the correct results.	Be sure the correct angle units are selected— degrees, radians, or grads.
The calculator produces hexadecimal digits when you attempt to enter square, square root, or trig functions.	Be sure the calculator is not set to the hexadecimal number base.
An error occurs.	Check the error conditions listed in Appendix A.
The calculator keyboard does not respond to key presses.	If a lengthy integration is in progress, the display may be blank for a noticeable duration. If you are not integrating, try pressing [2nd] [OFF] and then press [ON]. You can also try removing the battery and reinserting it.

You also should review the operating instructions in this guidebook to be sure that you are performing the calculations correctly.

Product Support

Customers in the U.S., Canada, Puerto Rico, and the Virgin Islands

For general questions, contact Texas Instruments Customer Support:

phone: **1–800–TI–CARES (1–800–842–2737)**
e-mail: **ti-cares@ti.com**

For technical questions, call the Programming Assistance Group of Customer Support:

phone: **1–972–917–8324**

Customers outside the U.S., Canada, Puerto Rico, and the Virgin Islands

Contact TI by e-mail or visit the TI **calculator** home page on the World Wide Web.

e-mail: **ti-cares@ti.com**
Internet: **www.ti.com/calc**

Product Service

Customers in the U.S. and Canada Only

Always contact Texas Instruments Customer Support before returning a product for service.

Customers outside the U.S. and Canada

Refer to the leaflet enclosed with this product or contact your local Texas Instruments retailer/distributor.

Other TI Products and Services

Visit the TI **calculator** home page on the World Wide Web.

www.ti.com/calc

Refer to the leaflet enclosed with this product or contact your local Texas Instruments retailer/distributor.

Customers in the U.S. and Canada Only

One-Year Limited Warranty for Electronic Product

This Texas Instruments ("TI") electronic product warranty extends only to the original purchaser and user of the product.

Warranty Duration. This TI electronic product is warranted to the original purchaser for a period of one (1) year from the original purchase date.

Warranty Coverage. This TI electronic product is warranted against defective materials and construction. **THIS WARRANTY IS VOID IF THE PRODUCT HAS BEEN DAMAGED BY ACCIDENT OR UNREASONABLE USE, NEGLECT, IMPROPER SERVICE, OR OTHER CAUSES NOT ARISING OUT OF DEFECTS IN MATERIALS OR CONSTRUCTION.**

Warranty Disclaimers. ANY IMPLIED WARRANTIES ARISING OUT OF THIS SALE, INCLUDING BUT NOT LIMITED TO THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, ARE LIMITED IN DURATION TO THE ABOVE ONE-YEAR PERIOD. TEXAS INSTRUMENTS SHALL NOT BE LIABLE FOR LOSS OF USE OF THE PRODUCT OR OTHER INCIDENTAL OR CONSEQUENTIAL COSTS, EXPENSES, OR DAMAGES INCURRED BY THE CONSUMER OR ANY OTHER USER.

Some states/provinces do not allow the exclusion or limitation of implied warranties or consequential damages, so the above limitations or exclusions may not apply to you.

Legal Remedies. This warranty gives you specific legal rights, and you may also have other rights that vary from state to state or province to province.

Warranty Performance. During the above one (1) year warranty period, your defective product will be either repaired or replaced with a reconditioned model of an equivalent quality (at TI's option) when the product is returned, postage prepaid, to Texas Instruments Service Facility. The warranty of the repaired or replacement unit will continue for the warranty of the original unit or six (6) months, whichever is longer. Other than the postage requirement, no charge will be made for such repair and/or replacement. TI strongly recommends that you insure the product for value prior to mailing.

Software. Software is licensed, not sold. TI and its licensors do not warrant that the software will be free from errors or meet your specific requirements. **All software is provided "AS IS."**

Copyright. The software and any documentation supplied with this product are protected by copyright.

All Customers Outside the U.S. and Canada

For information about the length and terms of the warranty, refer to your package and/or to the warranty statement enclosed with this product, or contact your local Texas Instruments retailer/distributor.

Index

You can use the Index to find page references for functions represented by display symbols, and also for specific topics. For additional page references, refer to the Key Index on the inside front cover.

List of Display Symbols