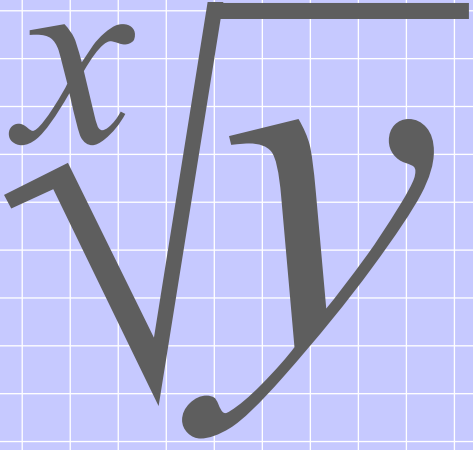
SCIENTIFIC, UNITS, LOGIC CALCULATOR
for iPhone, iPod touch, iPad and Apple Watch

MODEL SC-323PU

OPERATION MANUAL



INTRODUCTION

Thank you for the purchase of the scientific calculator App SC-323PU.

It converts your iPhone, Apple Watch, iPod touch, iPad and Mac into a pocket calculator and is designed in a way, that it simulates the visual and operational aspects of a true pocket calculator, such that the user will be immediately familiar with its interface.

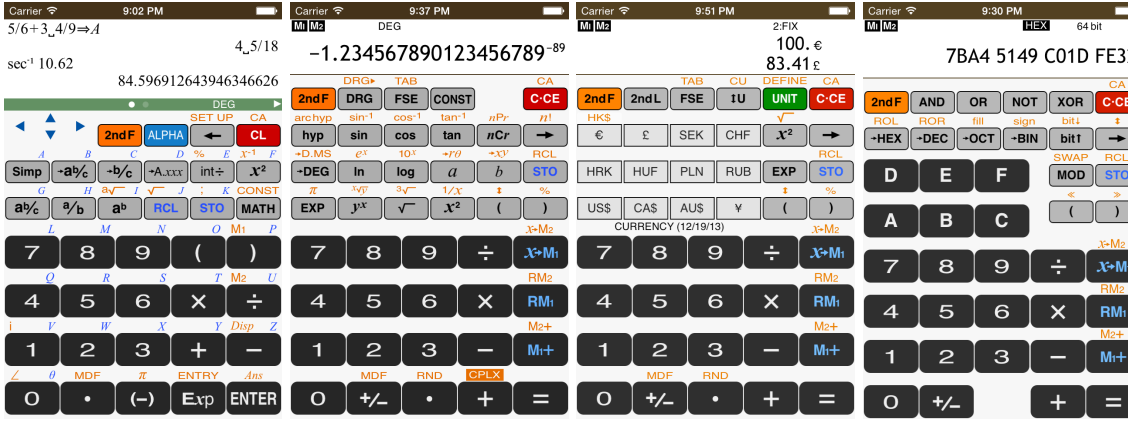
This manual will introduce you to the SC-323PU scientific calculator App.

- This manual will automatically be displayed if you rotate your device to landscape orientation. On the Mac it can be opened from the Help menu.
- Do a drag left or drag right gesture to see the next or previous page.
- Tap on the page do navigate to a specific page within the manual.
- Rotate the iPhone or iPod touch to portrait orientation to switch back to the calculator.

CONTENTS

CHAPTER 1
CALCULATOR MODES

The calculator SC-323PU offers four general modes for different tasks and further an extension for the Apple Watch (see chapter 6 “Apple Watch CALCULATOR”).



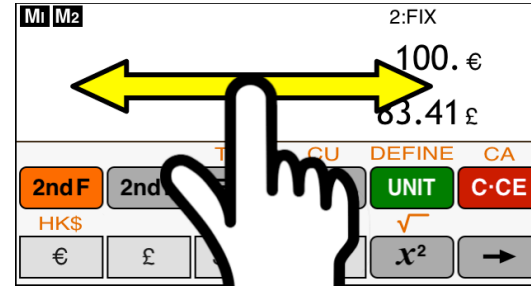
D.A.L. *Scientific* *Unit* *Logic*

The individual calculator modes are:

- DIRECT ALGEBRAIC LOGIC (D.A.L.)
- SCIENTIFIC MODE
- UNITS MODE
- LOGIC MODE

Switching Between the Calculator Modes

The calculator modes are presented as four different pocket calculators. Only one of the three calculator modes is visible and active at a time, but another one can be made visible and active by performing a horizontal swipe over the screen. This is best done in the display area of the calculator, because this area is not otherwise sensible to input and therefore false inputs can be avoided.



Features of the Calculator Modes

Scientific, Units and Logic mode use traditional sequential algebraic input logic. Here the calculation will be performed already during entry as far as possible.

In contrast to this, the SC-323PU also offers an operating mode with direct algebraic input logic (D.A.L.). Here the complete algebraic expression will be entered first and only after pressing the ENTER key, the calculation will be executed. This allows to make corrections during entry and gives the possibility to reuse and modify already used expressions.

1. General Features of all Modes

- Four arithmetic calculations, constant calculation, memory calculation.
- Priority of calculations according to a given mathematical formula.
- 30 levels of parentheses or pending operations.
- Two independently accessible memories for memory calculations.
- Additional memory slots to store values.
- All modes share the same memory contents, and calculation value, so that different calculator modes can be used in one calculation task.
- Values can be exchanged with the pasteboard.

2. Scientific Mode and D.A.L. Mode

- Floating decimal point calculations (20 digits mantissa and 2 digits exponent).
- Calculations: Trigonometric and inverse trigonometric functions, hyperbolic and inverse hyperbolic functions, conversion of angles and time, reciprocals, square roots and cubic roots, xth roots of y ($\sqrt[x]{y}$), squares and powers, logarithmic and exponential functions, factorials, permutations, combinations, conversions of coordinates, memory calculations.
- Calculations with complex numbers including powers, logarithmic, trigonometric and hyperbolic functions.
- DEG/RAD/GRAD selection.
- Different display modes selectable: floating point decimal, fixed point decimal, scientific notation and engineering notation.
- 47 physical constants are available.
- In D.A.L. Mode additionally:
  - Calculations with fractions and conversions between display of fractions or decimal results.
  - Simplifying of fractions
  - Greatest common divisor and least common multiple.

- Math menu with additional calculation functions.
- AER (Algebraic Expression Reserve) to save and reuse own algebraic expressions.
- Variables A to Z and θ.

3. Units Mode

- Conversions between different units including currencies.
- Time calculations (including frame rate calculations).
- Calculations with mixed units.
- The calculator is shipped with 84 physical units and 16 SI prefixes predefined.
- Exchange rates of currency units will be updated automatically from internet.
- Additional units can be defined by user.
- Single and two lines view modes optimized for different conversion tasks.
- Different display modes selectable: floating point decimal, fixed point decimal, scientific notation and engineering notation.

4. Logic Mode

- Conversions between 4 base systems HEX, DEC, OCT, BIN.

- Basic arithmetic operations including modulo division.
- Boolean operations AND, OR, XOR, NOT; bit shift and rotate operations.
- Conversion from “little endian” to “big endian” format and vice versa.
- Handling of 8, 16, 32 and 64 bit modes, including overflow calculations.
- Signed/unsigned mode.

CHAPTER 2
DIRECT ALGEBRAIC LOGIC (D.A.L.)

In D.A.L.-Mode scientific calculations can be performed using direct algebraic input logic. The calculator additionally offers a scientific mode with sequential algebraic entry, which will be described in the next chapter.

A Quick Tour

This section takes you on a quick tour covering the calculator‘s simple arithmetic operations and also principal features. It is designed to familiarize you with the calculator‘s operation keys, display and symbols.

Entering and solving an expression

Arithmetic expressions should be entered in the same order as they would normally be written in. To calculate the result of an expression, press ENTER at the bottom right of the keypad.

Example:

Find the answer to the expression:

$8^2 \div \sqrt{3} - 7 \times -10.5$

1. [8] [x^2] [÷] [2nd F] [RCL] [3] [–]
   [7] [×] [(–)] [1] [0] [•] [5]

$8^2 \div \sqrt{3} - 7 \times -10.5$

- The square root symbol "√" is printed in orange above the [RCL] key. The symbols identified by orange letters can be used by first pressing the orange [2nd F] key, and then pressing the required key. When the [2nd F] key is pressed, the designation "2ndF" should appear in the lower part of the display.
- Note that "$\sqrt{3}$" is entered in the same order as in a written equation.
- This calculator has a minus key [–] for subtraction and a negative key [(–)] for entering negative numbers.
- You can review the expression to correct any mistakes in the input numbers or symbols.
- To correct an error, use the cursor keys ◄ ▲▼ ► to move to the appropriate position on the display and type in the missing signs or delete the sign before the cursor using the [←] key.

2. Press **ENTER** to obtain an answer.
   - In this operating mode, you can see both the expression and its answer in the same display.
   - If your answer exceeds 20 digits, the 21st digit will be rounded.

```
8² ÷ √3 – 7 × -10.5
                    110.45041722813604893
```

Editing an expression

After obtaining an answer, you can go back to an expression and modify it using the cursor keys.

Example:

Return to the last expression and change it to:
$8^2 \div \sqrt{3 - 7 \times -10.5}$

1. Press ▼ or ▶ to return to the last expression.
   - The cursor is now at the beginning of the expression (before “8” in this case).
   - Pressing ▲ or ◀ after obtaining an answer returns the cursor to the end of the last expression, i.e. “5” in this example.

```
8² ÷ √3 – 7 × -10.5
                    110.45041722813604893
|8² ÷ √3 – 7 × -10.5
```

2. Press ▶ four times to move the cursor to the point where you wish to make a change.
   - The cursor has moved four places to the right and is now flashing in front of “3”.

```
8² ÷ √3 – 7 × -10.5
                    110.45041722813604893
8² ÷ √|3 – 7 × -10.5
```

3. Press [( ] and then move the cursor behind the end of the expression. For this you can press the keys [2nd F] ▶.

```
8² ÷ √3 – 7 × -10.5
                    110.45041722813604893
8² ÷ √(3 – 7 × -10.5|
```

4. Press [ )] and [ENTER] to find the answer for the new expression.

```
8² ÷ √3 – 7 × -10.5
                    110.45041722813604893
8² ÷ √(3 – 7 × -10.5)
                    7.3172729660803770615
```

Note:
It is also possible to use the common touch based editing features of iOS additionally to the one shown before. This allows to select text ranges and to copy and delete them.

Using Variables

You can use 27 variables (A to Z and θ) in D.A.L. mode. A number stored as a variable can be recalled either by entering the variable name or using [RCL].

Example:

Store 2^3 to variable R.

1. Press [2] [a^b] [3] then [STO] .
   - Note that "2^3" represents 2 to the 3rd power.
   - When pressing [STO], ALPHA will automatically appear below the display. Now a character written in blue can be entered.

```
2^3⇒|
                    ALPHA
```

```
2^3⇒R
                        8
```

2. Press [5] to store the result in R.
   - The stored number is displayed in the next line.
   - ALPHA disappears and the calculator returns to normal entering mode.

Enter an expression containing variable R (now equal to 8) from the last example.

Example:

Find the area of a circle which has radius R.

1. Press [2nd F] [(–)] then [ALPHA] .
   - To enter a character written in blue above a key you have to press [ALPHA] first. ALPHA appears below the Display.
2. Press [5] and then [x^2] .
   - ALPHA disappears after you have entered the character. The calculator returns to normal entering mode.
3. Press [ENTER] to obtain the result.

π ALPHA
πR^2
πR^2 201.06192982974676726

Instead of entering a variable directly as above, you can use it indirectly, i.w. by recalling it and then using the recalled value. For this press:

	π			R		
2nd F	(–)	×	RCL	5	x^2	ENTER

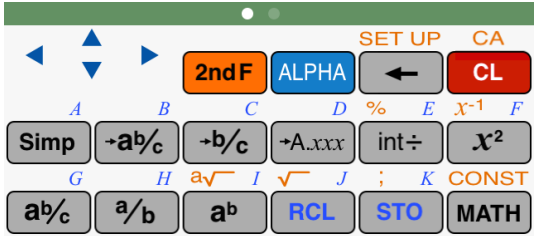
You will get the same result.

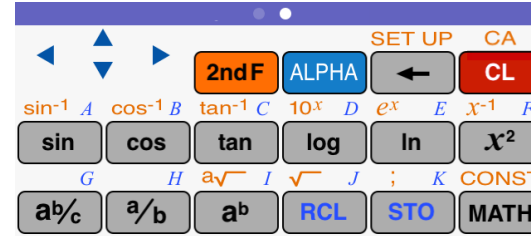
$\pi \times 8^2$

201.06192982974676726

Other Features

The calculator has two function button areas in D.A.L. mode:





The first one is marked with a green bar and offers mainly keys for fraction calculations. The second one marked with a blue bar contains mainly keys for trigonometric functions and logarithms. To switch between the two areas tap onto the two dots in the colored bar or swipe the buttons to the left or right.
Some often used functions for example x^2 are part of both areas.

Calculator Keys

There are three broad groups of key functions: ① first function, ② second function and ③ variable (ALPHA).

Key notation in this manual

To perform the second or variable functions shown in orange or blue above the keys, you have to press [2nd F] or [ALPHA] followed by the key.

In this manual the first function of a key, excluding number keys, the decimal point key and the negative key will be shown in a box:

[7] [×] [(–)] [1] [0] [•] [5] → 7 [×] -10.5

The second function of a key is shown as follows:

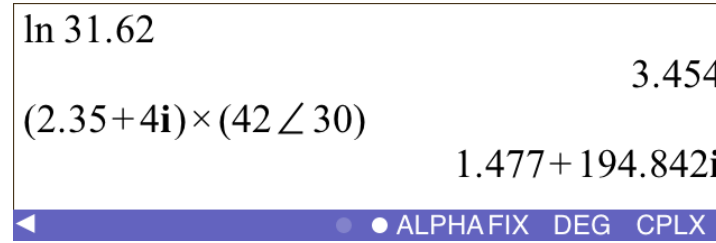
[2nd F] [(–)] → [2nd F] [π]

The ALPHA function of a key is shown as follows:

[ALPHA] [5] → [ALPHA] [R]

Calculator Display

The D.A.L. mode has a display of multiple lines. Normally the last entries and results will be displayed but the contents of the display can be scrolled down using a vertical swipe gesture to view older entries.



There are also symbols below the display to indicate the status of the calculator:
2ndF or **ALPHA** appears when you press [2nd F] or [ALPHA] respectively to conform the key function mode the calculator is in. **RCL** is displayed when you press [RCL] to show that the value stored in a variable or memory should be recalled. **DEG**, **RAD** or **GRAD** indicates the currently selected angular unit. Further the currently selected display mode for the result of a calculation: **FIX** for fixed point decimal, **SCI** for scientific notation and **ENG** for engineering notation or no indicator for floating point decimal system (normal mode). **CPLX** indicates that the calculator is set up for complex calculations.

Precedence of Calculations

The calculator always performs calculations in the standard arithmetic order, even though this may not be the order in which you entered them.
Direct Algebraic Logic uses the following order of precedence in solving an expression (sorted from highest to lowest):

1. Fractions (1/4, A/B, ␣, etc.)
2. Complex angles (∠)
3. Single calculation functions after a numerical value (x^2, x^{-1} and $n!$)
4. Exponential functions (a^b, $\sqrt[a]{\ }$, etc.)
5. Implicit multiplications between a value and a stored variable/constant (2π, $2A$, etc.)
6. Single calculation functions before a numerical value (sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$, log, 10^x, ln, e^x, $\sqrt{\ }$, abs, int, ipart, fpart, (–) etc.)
7. Implicit multiplication between a number and a function in #5 (3cos20, etc. where "cos20" is evaluated first)
8. Permutations and combinations (nPr, nCr)
9. Multiplication and Division (×, ÷)
10. Addition and Subtraction (+, –)

Example

Let us examine the order in which the calculator performs the operations of a computation.

$$\underbrace{\underbrace{\underbrace{1/2}_{①} + \underbrace{\underbrace{2^3}_{②} \times \underbrace{\sqrt{25}}_{③}}_{④\ (②\times③)}}_{⑤\ (①+④)} - \underbrace{3^2}_{⑥}}_{⑦\ (⑤-⑥)} \underbrace{= 31.5}_{⑧}$$

Calculations will be performed in the order from ① to ⑧.

Using Parentheses

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

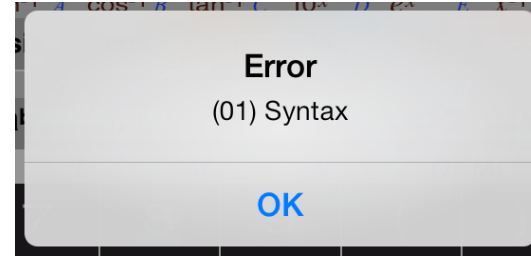
$$1/2 + 2^3 \times (\sqrt{25} - 3^2) = -31.5$$

Error Messages

The calculator will display an error message when a given command is handled incorrectly, or when instructions cannot be handled correctly such that the task cannot be processed further. Various types of error messages are given to inform users the types of situations to be remedied. For example, performing the following key strokes:

[3] [×] [ENTER]

will result in an error, and the error message will be displayed. For a list of various error codes and messages, refer to the appendix “Error Codes and Error Messages”.



Entering Numbers

Use the number keys ([0] ~ [9]), decimal point key ([•]), and negative number key ([(–)]) to enter numbers into the calculator. To clear the screen entry, press [CL].

Example: Type 10.23456789 onto the calculation screen using the number keys and decimal point key, as follows:
10 [•] 23456789

```
10.23456789|
```

Note: [Exp] can be used to enter a value in scientific notation.

Example: $6.3\times10^8 + 4.9\times10^7$
[CL] 6.3 [Exp] 8 [+] 4.9 [Exp] 7

```
6.3E8 + 4.9E7|
```

Entering a Negative Value

The negative number key [(–)] can be used to enter numbers and functions with negative values. Press [(–)] before entering the value.

Note: Do not use the [–] key to specify a negative value. Doing so will result in an error.

Example: Type -9460.827513 into the calculation screen.
[CL] [(–)] 9460.827513

-9 460.827513

Editing Entries

Cursor Navigation

- You can move the cursor using the cursor keys ◀ ▲ ▼ ▶ .
- You can jump the cursor to the beginning or end of line by using [2nd F] ◀ and [2nd F] ▶ keys.
- You can also move the cursor with your finger. For this press and hold at a location within the input line. A loupe will appear, the cursor will be set to the position where you pressed and the cursor will follow your finger movements.
- With the [←] key the character before the cursor can be deleted.
- With [CL] the whole line and with [2nd F] [CA] the whole display will be deleted.

- Function names like “sin”, “$\tan^{-1}$”, “round(”, etc. will be handled like a single character, this means the cursor cannot be positioned within the function name and [←] always deletes the function as a whole.

Recalling Previous Entries

1. [2nd F] [ENTRY] recalls the previous entry. This is useful when you want to modify the previous entry, rather than reenter the whole expression over.
   You can press [2nd F] [ENTRY] more then once to recall older entries.
2. After obtaining an answer, you can go back to the last expression and modify it using the cursor keys:
   - By pressing the ▲ or ◀ key the last entry will be recalled and the cursor will be positioned at the end of the expression.
   - By pressing the ▼ or ▶ key the last entry will be recalled and the cursor will be positioned at the beginning of the expression.
3. The display of the calculator can be scrolled back to reveal older expressions and results. If you do a double tap on such an entry or result then a menu will be displayed. With this menu the entry can be copied to the pasteboard or to the current input line.

SET UP Menu

Use this menu to verify basic configurations, such as to define the calculator's angular unit, the number format for results, the display format for fractions and to reset settings and memory contents.
To show the SET UP menu press [2nd F] then [SETUP].

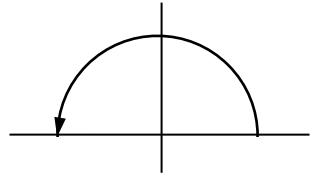
SET UP Menu Items

Angular unit For trigonometric calculations various angle units can be selected:

Degrees (DEG) (default)
Radians (RAD)
Gradients (GRAD)

The abbreviations in parentheses are displayed as indicators below the display to give a quick response of the selected angular unit without the need to open the SET UP menu.

$180° = \pi$ (rad) = 200^g



DEG: Degree [°]
RAD: Radians[rad]
GRAD: Gradients [g]

Number format

Various decimal formats can be set:

Floating point Answers are given in decimal form with a floating decimal point (default).

Fixed (FIX) Answers are given in decimal form. The decimal point can be set in the TAB menu.

Scientific (SCI) Answers are given in “scientific” notation. For example, “3500” is displayed as “3.500E03”. The decimal point can be set in the TAB menu.

Engineering (ENG) Answers are given in “engineering” notation with exponents set to be multiples of 3. “100000” will be displayed as “100.000E03”, and “1000000” will be shown as “1.000E06”. The decimal point can be set in the TAB menu.

Notes: The abbreviations given in parentheses will be shown as indicators below the display.

If the value of the mantissa does not fit within the range ±0.0000000000000000001 to ±9999999999999999999, the display changes to scientific notation.

Fractional digits (TAB)

Sets the number of decimal places (0 through 9). The default is “3”.

Answer

Sets the answer preference to various number formats:

Decimal (Real) Answers will be given in decimal form.

Mixed fraction (Real) Answers will be given in mixed fractions, whenever appropriate (default)

Improper fraction (Real) Answers will be given in improper fractions, whenever appropriate.

$x \pm y$**i (Complex)** Answers will be given in complex rectangular form.

$r\angle\theta$ **(Complex)** Answers will be given in complex polar form.

Auto simplify fractions

Sets the preference for handling reducible fractions. If this option is switched on, fractions will automatically be reduced down (default).

Otherwise fractions will not be reduced unless Simp is pressed.

- Note that the number of decimal places affects the result of the modify command [2nd F] [MDF] (see page 49).
- The settings for **Angular unit**, **Number format** and **Fractional digits (TAB)** also affect the corresponding settings of the scientific mode.

Device status bar

If this option is switched on the iOS status bar will be shown (default), otherwise no status bar will be shown and the display of the calculator can contain one additional visible line.

Key click sound

Sound that should be played as indicator for a key press:
None for no indication sound.
Standard key click sound of iOS (default).
Beep when key is pressed.

Reset

Delete calculations Clears the calculation history buffer.
Clear variables and memories The content of all variables (A to Z, θ) and memories M_1 and M_2 will be cleared (set to 0).
Reset settings All settings of the SET UP menu will be reset to default values.

USING MEMORIES

THE CALCULATOR USES GLOBAL VARIABLE MEMORIES ($A - Z$ and θ), the independent memories M1 and M2, and the "last answer" memory used when solving equations.

Using Alphabetic Characters

You can enter an alphabetic character (written in blue) when ALPHA is displayed below the display. To enter this mode, press [ALPHA].

```
                                        0
|
                          ALPHA
```

Using Global Variables Indirectly

You can assign values (numbers) to global variables by pressing [STO] then $A - \theta$.

Example:
Store 6 to global variable A.
Press [CL] 6 [STO] [A]

```
6⇒A
                                        6
```

To recall global variables, press [RCL] then $A - \theta$.

Example:
Recall global variable A.
1. Press [RCL]
   - RCL and ALPHA appear below the display.
2. Press [A] .

```
|
                RCL      ALPHA
```

```
6
```

Using Variables Directly

Both global variables and memories can be used directly in an equation.

Example:
Using A (6) from the last example, solve the Expression:
$9\times10^6 - 1000A$.

Press [CL] 9 [Exp] 6 [–] 1000 [ALPHA] [A] [ENTER] .

```
9E6 – 1 000A
                    8 994 000
```

Using “last answer” Memory

The calculator always keeps the most recent answer in *Ans* memory and replaces it with the new answer every time you press [ENTER]. You may recall the last answer and use it in the next equation.

Example:

A cylinder with radius $r = 3$ and height $h = 5$. Evaluate the base area ($S = 3^2\pi$) and volume ($V = 5S$) of this cylinder using "last answer".

1. Press [CL] 3 [x^2] [2nd F] [π] [ENTER].
   - The area of the base is now calculated.
   - The number 28.274333882308139146 is held in *Ans* memory.

$3^2\pi$
28.274333882308139146

2. Press [CL] 5 [2nd F] [*Ans*] [ENTER].
   - Now you have the volume of the cylinder.
   - The last answer is not cleared merely by pressing [CL].

$3^2\pi$
28.274333882308139146
$5Ans$
141.37166941154069573

The last answer is cleared (i.e. set to 0) if you activate in the SET UP menu under

Reset the entry **"Clear variables an memories"**, but not when closing the App or changing the operating mode.

Exchange of Saved Values With The Other Operating Modes

The independent memories M_1 and M_2 of the other operating modes can also be accessed in D.A.L.mode.

Example:

Storing the value 3 in the first independent memory:

3 [STO] [2nd F] [M1]

$3 \Rightarrow M_1$
3

The value stored in the independent memories can be used directly and indirectly.

Example: Multiply the value stored in the independent memory M_1 with 5.

[RCL] [2nd F] [M1] [×] 5 [ENTER]

- Indirect usage.

[2nd F] [M1] [×] 5 [ENTER]

- Direct usage.

3×5
15
$M_1 \times 5$
15

The second independent memory M2 can be used in the same way.

The content of the variables that are related to the number keys (7: L, 8: M, 9: N, 4: Q, 5: R, 6: S, 1: V, 2: W, 3: X and 0: θ) is identical with the content of the memory registers that are assigned to the number keys in the other operating modes. This means, that the value stored in variable L can for example be recalled in units mode by pressing [2nd F] [RCL] [7] . Further when storing a value in one of this memory registers the corresponding variable will also be set.

Using the Displayed Value of Other Operating Modes

The calculator always keeps the value currently displayed in scientific, units or logic mode in the variable "*Disp*". The variable "*Disp*" can only be recalled not stored. It can be accessed directly by pressing [2nd F] [*Disp*], and indirectly by pressing [RCL] [2nd F] [*Disp*] .

Mathematical Operations

1. Arithmetic Keys

There are various keys for arithmetic calculations. Use the [+] [−] [×] [÷], [(−)], [(] and [)] keys to perform basic arithmetic calculations. Press [ENTER] to solve an equation.

✳ [ENTER] Executes an expression.

Example: Calculate 1 + 2.
[CL] 1 [+] 2 [ENTER]

```
1 + 2
                                3
```

A note about expressions: An expression is a mathematical statement that may use numbers and/or variables that represent numbers. A math expression needs to be complete. 1×2, $4x$, $2\sin x \times \cos x$ form valid expressions, while "$1 \times$" and "$\cos$" do not. If an expression is not complete, the calculator will display an error message upon pressing the [ENTER] key.

✳ [+] Enters a “+” sign for addition.

Example: Calculate 12 + 34.

[CL] 12 [+] 34 [ENTER]

12 + 34	
	46
43 – 21	
	22

✳ [–] Enters a “–” sign for subtraction.

Example: Subtract 21 from 43.

43 [–] 21 [ENTER]

✳ [×] Enters a “×” sign for multiplication.

Example: Multiply 12 by 34.

12 [×] 34 [ENTER]

12 × 34	
	408
54 ÷ 32	
	1.6875

✳ [÷] Enters a “÷” sign for division.

Example: Divide 54 by 32.

54 [÷] 32 [ENTER]

When to leave out the "×" sign

The multiplication sign can be left out when:

a. It is placed in front of an open parenthesis.

b. It is followed by a variable or a mathematical constant (π, e, etc.).

c. It is followed by a scientific function, such as sin, log, etc.

$2(3+4)$
14
$(X-3)(X+4)$
-12

$2A$
49 675.2
3π
9.4247779607693797154
$2\log 10$
2

Entering a number with a negative value

✳ [(–)] Sets a negative value.

Example: Calculate -12 × 4.

[(–)] 12 [×] 4 [ENTER]

-12 × 4
-48

Note: Do not use the [−] key to enter a negative value; use the [(−)] key instead.

✳ [( ] Enters an open parenthesis. Use with ")" as a pair, or the calculation will result in an error.

✳ [ )] Enters a closing parenthesis; a parenthesis left open will result in an error.

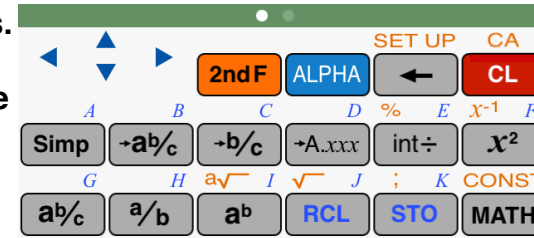
Example: Calculate (4 + 6) ÷ 5.
[( ] 4 [+] 6 [ )] [÷] 5 [ENTER]

(4 + 6) ÷ 5
2

Note: Functions, such as "round(", automatically include an open parentheses. Each of these functions needs to be closed with a closing parentheses.

2. Calculations Using Various Function Keys

The calculator has two function key areas. The first one marked with a green bar is specially designed to help you learn/solve fraction calculations easier.



✳ [Simp] Simplifies a given fraction stored in the "*Ans*" memory. *(Set "**Auto simplify fractions**" to off in the SET UP menu to use this key.)*

Specifying no common factor

Simplify the fraction using the lowest common factor other than 1.

Example:

1 [a/b] 12 [+] 5 [a/b] 12 [ENTER]

[Simp] [ENTER] (Simplified by 2, the lowest common factor of 12 and 6.)

[Simp] [ENTER] (Simplified by 3, the lowest common factor of 6 and 3.)

```
                    6/12
Simp
                Factor=2
                     3/6
```

```
                     3/6
Simp
                Factor=3
                     1/2
```

Specifying a common factor

Simplify the fraction using the specified common factor.

Example:

1 [a/b] 12 [+] 5 [a/b] 12 [ENTER]

[Simp] 6 [ENTER] (Manually specify 6, the Greatest Common Factor of 12 and 6, to simplify the fraction.)

```
                    6/12
Simp 6
                Factor=6
                     1/2
```

Note: If the wrong number is specified for a common factor, an error will occur.

[Simp] is effective in a fraction calculation mode only (when the **Answer** mode is set to "**Mixed fraction**" or "**Improper fraction**" in the SET UP menu).

✳ [→ab/c] Converts an improper fraction to a mixed number.

Example: Change $^{12}/_{5}$ to a mixed number.
12 [a/b] 5 [→ab/c] [ENTER]

```
12/5→a␣b/c
                    2␣2/5
```

✳ [→b/c] Converts a mixed number to an improper fraction.

Example: Change $2^{2}/_{5}$ to an improper fraction.
[→b/c] [ENTER]

```
Ans→b/c
                    12/5
Ans→A.xxx
                    2.4
```

✳ [→A.xxx] Converts a fraction to a decimal number.

Example: Change $^{12}/_{5}$ to a decimal number.
[→b/c] [ENTER]

Note: Above three conversions will not affect the **Answer** settings in the SET UP menu. If a decimal number is not rational, fraction conversion will not function and display the answer in decimal format.

✳ [int÷] Performs an integer division, and returns a quotient and a remainder.

Example: Get a quotient and a remainder of 50 ÷ 3.
50 [int÷] 3 [ENTER]

```
50 int÷ 3
                    Quotient: 16
                  Remainder: 2
```

Quotient value is set to "*Ans*" memory and remainder is not stored.

✳ [x^2] Squares the preceding number.

Example: Obtain the answer to 12^2. (= 144)
12 [x^2] [ENTER]

✳ [ab/c] Enters a mixed number.

The key [ab/c] enters " ␣ " only (integer-fraction separator). Use [ab/c] in combination with [a/b] as follows.

Example: Enter $4\frac{5}{6}$.
4 [ab/c] 5 [a/b] 6 [ENTER]

```
4␣5/6
                    4␣5/6
```

- Integer part of the mixed number must be a natural number. A variable can not be used. Equation or use of parenthesis, such as (1 + 2)␣2/3 or (5)␣2/3, causes syntax error.
- When numerator or denominator is negative, the calculator will cause error.

✳ [a/b] Enters a fraction, setting the preceding number as its numerator.

Example: Calculate $^2/_5 + {}^3/_4$.

2 [a/b] 5 [+] 3 [a/b] 4 [ENTER]

```
2/5 + 3/4
                    1␣3/20
```

✳ [a^b] Enters an exponent, setting the preceding number as its base.

Example: Raise 4 to the 5th power.

4 [a^b] 5 [ENTER]

Calculate 2^{3^2} (= 512)

2 [a^b] [(] 3 [a^b] 2 [)] [ENTER].

If you wish to calculate $(2^3)^2 = 2^8$,

press 2 [a^b] 3 [a^b] 2 [ENTER]

```
4^5
                    1 024
2^(3^2)
                    512
2^3^2
                    64
```

✳ [;] Enters a semicolon " ; " at the cursor. A semicolon is required in some of the MATH functions. For more information, refer to the next section "Calculations Using MATH Menu Items" in this chapter.

✳ [STO] Stores a number in a variable or memory. For further information see previous section "Using Memories" in this chapter.

✳ [%] Set the preceding value as a percentage.

Example: Calculate 25% of 1234.
1234 [×] 25 [2nd F] [%] [ENTER]

Example: Percentage decrease of 200 by 30%: $200 - 200 \times \frac{30}{100}$

200 [−] 30 [2nd F] [%] [ENTER]

1 234 × 25%	
	308.5
33%	
	0.33
200 – 30%	
	140

✳ [x^{-1}] Enters "x^{-1}", and returns an inverse by raising a value to the (-1) power. The inverse of "5", for example, is "$^1/_5$".

Example: Raise 12 to the -1 power. (= 0.0833333333333333333)
12 [2nd F] [x^{-1}] [ENTER]

✳ [$\sqrt[a]{\ }$] Enters "$\sqrt[a]{\ }$".

Example: Bring 4 to the 5th root. (= 1.3195079107728942594)
5 [2nd F] [$\sqrt[a]{\ }$] 4 [ENTER]

✳ [$\sqrt{\ }$] Enters a square root symbol.

Example: Obtain the square root of 64. (= 8)
[2nd F] [$\sqrt{\ }$] 64 [ENTER]

✳ [RCL] Recalls a variable or memory. For further information see previous section "Using Memories" in this chapter.

✳ [MDF] Modify function. The calculator holds all calculation results internally in scientific notation with 22 digits for the mantissa. The modify function converts the internal value (22 decimal places) to match that of the display (number of decimal places selected in SET UP menu), so that the displayed value can be used exactly as you see it in subsequent operations. This function is useful for calculations in which not all the significant digits of a number need to be taken into account.
If the modify function is not used, the internal result rather than the displayed result is used in subsequent calculations.

By using the modify function [2nd F] [MDF], the internal value is converted to match that of the display, so that the displayed value can be used without change in subsequent operations.

a) Set the display to FIX format with one decimal place: Press [2nd F] [SETUP] and for "**Number format**" select the entry "**Fixed (FIX)**". For "**Fractional digits (TAB)**" select "**1**". Press "**Done**" to close. (FIX is displayed below the display.)

b) Press 5 [÷] 9 [ENTER] [×] 9 [ENTER] .

- The calculator obtains 0.5555555555555555555556 as the internal result of 5 ÷ 9 and displays it as 0.6.
- The internal result is multiplied by 9 to give a result of 5.0 (the first number you entered).

```
5 ÷ 9
                                0.6
Ans × 9
                                5.0
                          FIX
```

c) Press 5 [÷] 9 [ENTER] [2nd F] [MDF] [×] 9 [ENTER] .

- The modify function substitutes the displayed result (0.6) for the internal result.
- The calculator multiplies 0.6 by 9 to give 5.4.

```
5 ÷ 9
                                0.6
                                0.6
Ans × 9
                                5.4
                          FIX
```

✳ [M1], [M2] Recall from, or store to the two independent memories M_1 or M_2. For further information see previous section "Using Memories" in this chapter.

✳ [Disp] Recalls the value that is currently displayed in the other operating modes. For further information see previous section "Using Memories" in this chapter.

✳ [Ans] Recalls the previous answer. Use this key to incorporate the answer to the previous calculation into an expression.

Example: Perform "3 × 3".
3 [×] 3 [ENTER]
Subtract the value of the previous answer from "10".
10 [−] [2nd F] [Ans] [ENTER]

3×3	
	9
$10 - Ans$	
	1
$Ans + 4$	
	5

Note: [Ans] can be considered as a variable; its value is automatically set when [ENTER] is pressed. If [Ans] is not empty, then pressing [+], [−], [×] or [÷] will recall "*Ans*" and places it at the beginning of an expression. If "1" was the previous answer, then pressing [+] 4 [ENTER] will result in "5".

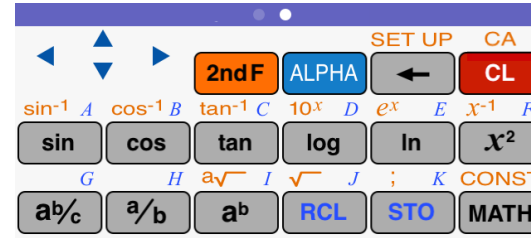
✳ [ENTRY] Recalls the previous entry. This is useful when you want to modify the previous entry, rather than reenter the whole expression over. See subsection "Recalling Previous Entries" in section "Editing Entries" of this chapter for further information.

✳ [π] Enters "pi". Pi is a mathematical constant, representing the ratio of the circumference of a circle to its diameter (3.14…).

Example: Enter "2π". (= 6.2831853071795864769)

2 [2nd F] [π] [ENTER]

The second function key area, marked with a blue bar allows access to trigonometric and logarithmic functions. Some keys are equal to the one in the first function key area. They will not be explained again.



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

Example: Calculate sin 30°, cos π/2 and tan 150 grads.

1. Press [2nd F] [SETUP] and for "**Angular unit**" select entry "**Degrees (DEG)**"; close menu with "**Done**". (DEG is shown below the display.)
   Press [sin] 30 [ENTER] .

```
sin 30
                    0.5
                    DEG
```

2. Press [2nd F] [SETUP] and for "**Angular unit**" select entry "**Radians (RAD)**"; close menu with "**Done**". (RAD is shown below the display.)
   Press [cos] [2nd F] [π] [a/b] 2 [ENTER] .

```
cos π/2
                    0
                    RAD
```

3. Press [2nd F] [SETUP] and for "**Angular unit**" select entry "**Gradients (GRAD)**"; close menu with "**Done**". (GRAD is shown below the display.)
   Press [tan] 150 [ENTER] .

```
tan 150
                   -1
                    RAD
```

✳ [log] Enters a common logarithm function.

Example: [log] 31.62 [ENTER].

```
log 31.62
                    1.4999618655961902407
```

✳ [ln] Enters a natural logarithm function.

Example: [ln] 31.62 [ENTER].

```
ln 31.62
                    3.453789831781325959
```

✳ [sin⁻¹], [cos⁻¹] and [tan⁻¹] calculate the arcsine, arccosine and arctangent of a number. The result is always the smallest (positive or negative) angle that has a sine, cosine or tangent equal to the operand. You must set the desired angle unit beforehand.

Example: Calculate arcsine -1 in degrees.

Press [2nd F] [SETUP] and for "**Angular unit**" select entry "**Degrees (DEG)**"; close menu with "**Done**". (DEG is shown below the display.)
Press [2nd F] [sin⁻¹] [(–)] 1 [ENTER] .

```
sin⁻¹ -1
                                  -90
                                  DEG
```

✳ [10^x] Raises 10 to the power of x.

✳ [e^x] Enters the Euler Number e (2.71…) to a power.

Example: Obtain a value of e^3.
[2nd F] [e^x] 3 [ENTER] .

```
e^3
                    20.085536923187667741
```

3. Calculations Using MATH Menu Items

The MATH menu contains functions used for more elaborate math concepts, such as trigonometry, logarithms and probability. The MATH menu items may be incorporated into your expressions.

Calculation

The Calculation sub-menu contains items to be used in calculations containing trigonometric and logarithmic functions:

$\log_2$ **$\log_2$ *value***

Enters a base-2 logarithm ($\log_2$).

Example: Calculate $\log_2 32$.

[MATH] **Calculation → $\log_2$** 32 [ENTER]

$\log_2 32$
5
2^4
16

2^x **2^*value***

Raises 2 to a power.

Example: Calculate 2^4.

[MATH] **Calculation → 2^** [4] [ENTER]

Note: The default angle measurement unit of this calculator is degrees. If you wish to work in radians, then the configuration must be changed in the SET UP menu.

sec **sec** ***value***

Enters a secant function to be used in a trigonometric expression.

Example: Calculate sec 10.

[MATH] **Calculation ➔ sec** 10 [ENTER]

sec 10	
	1.0154266118857449852
csc 10	
	5.7587704831436335362
cot 10	
	5.671281819617709531
	DEG

csc **csc** ***value***

Enters a cosecant (cosec) function to be used in a trigonometric expression.

Example: Calculate cosec 10.

[MATH] **Calculation ➔ csc** 10 [ENTER]

cot **cot** ***value***

Enters a cotangent (cotan) function to be used in a trigonometric expression.

Example: Calculate cotan 10.

MATH **Calculation ➔ cot** 10 **ENTER**

sec^{-1} **sec^{-1} *value***
Enters an inverse secant.

csc^{-1} **scs^{-1} *value***
Enters an inverse cosecant.

cot^{-1} **cot^{-1} *value***
Enters an inverse cotangent.

sinh **sinh *value***
Enters a hyperbolic sine.

cosh **cosh *value***
Enters a hyperbolic cosine.

tanh **tanh *value***
Enters a hyperbolic tangent.

```
sec-1 10
                 84.260829522733213687
csc-1 10
                 5.7391704772667863125
cot-1 10
                 5.7105931374996425127
                                   DEG
```

```
sinh 10
                 11 013.232874703393377
cosh 10
                  11 013.23292010332314
tanh 10
                 0.9999999958776927636
```

sinh^{-1} **sinh^{-1}** ***value***

Enters an inverse hyperbolic sine.

cosh^{-1} **cosh^{-1}** ***value***

Enters an inverse hyperbolic cosine.

tanh^{-1} **tanh^{-1}** ***value***

Enters an inverse hyperbolic tangent.

Example: Calculate arctanh 0.05

[MATH] **Calculation ➔ tanh^{-1}** .05 [ENTER]

sinh^{-1} 1	
	0.8813735870195430252
cosh^{-1} 2	
	1.3169578969248167086
tanh^{-1} .05	
	0.0500417292784912682

Number

Use the sub-menu items below to convert a value:

abs(**abs(*value*)**

Returns an absolute value.

Example: Find an absolute value of "-40.5".

[MATH] **Number ➔ abs(** [(–)] 40. 5 [ )] [ENTER]

```
abs(-40.5)
                    40.5
```

round(**round(*value* [; *number of decimals*])**

Returns the rounded value of the term in parentheses. A rounding point can be specified.

Example: Round off 1.2459 to the nearest hundredth. (= 1.25)

[MATH] **Number ➔ round(** 1.2459 [2nd F] [;] 2 [ )] [ENTER]

ipart **ipart *value***

Returns only the integer part of a decimal number.

Example: Discard the fraction part of -7.94. (= -7)

[MATH] **Number ➔ ipart** [(–)] 7.94 [ENTER]

fpart **fpart *value***

Returns only the fraction part of a decimal number.

Example: Discard the integer part of -7.94. (= -0.94)

[MATH] **Number → fpart** [(–)] 7.94 [ENTER]

int **int *value***

Rounds down a decimal number to the closest integer.

Example: Round down -7.94 to the nearest whole number. (= -8)

[MATH] **Number → int** [(–)] 7.94 [ENTER]

min **min(*value1*; *value2*)**

Returns the lower one of two numbers.

Example:

[MATH] **Number → min(** 40.5

[2nd F] [;] 12.36 [)] [ENTER]

min(40.5; 12.36)
12.36
max(40.5; 12.36)
40.5

max **max(*value1*; *value2*)**

Returns the higher one of two numbers. **Example:**

[MATH] **Number → max(** 40.5

[2nd F] [;] 12.36 [)] [ENTER]

lcm(**lcm(*natural number*; *natural number*)**

Returns the least common multiple of two integers.

Example: Find the least common multiple of 12 and 18.

[MATH] **Number → lcm** 12 [2nd F] [;] 18 [)] [ENTER]

gcd(**gcd(*natural number*; *natural number*)**

Returns the greatest common divisor of two integers.

Example: Find the greatest common divisor of 16 and 36.

[MATH] **Number → gcd(** 16 [2nd F] [;] 36 [)] [ENTER]

```
lcm(12; 18)
                    36
gcd(16; 36)
                     4
```

remain ***natural number*** **remain** ***natural number***

Returns the remainder of a division.

Example: Obtain the remainder when 123 is divided by 5.

123 [MATH] **Number → remain** 5 [ENTER]

```
123 remain 5
                     3
```

Probability

Use the Probability sub-menu items for probability calculations:

random

Returns a random decimal number between 0 and 1.

Example: Create a random number between 0 and 1.
[MATH] **Probability ➔ random** [ENTER]

```
random
                    0.6635904359470315033
rndInt(1; 9)
                                         5
```

rndInt(rndInt(*minimum value*; *maximum value*)

Returns a specified number of random integers, between a minimum and a maximum value.

Example: Produce a random integer, ranging between values of 1 and 9.
[MATH] **Probability ➔ rndInt(** 1 [2nd F] [;] 9 [)] [ENTER]

rndCoin

Returns a random integer to simulate a coin flip: 0 (head) or 1 (tail).

rndDice

Returns a random integer (1 to 6) to simulate rolling dice. (The same as rndInt(1, 6)).

*n***P***r* Returns the total number of different arrangements (permutations) for selecting r items out of n items.

$$n\mathrm{P}r = \frac{n!}{(n-r)!}$$

Example: How many ways can 6 persons be seated in a car with 4 seats?

6 [MATH] **Probability ➔** *n***P***r* 4 [ENTER]

```
6P4
                    360
```

*n***C***r* Returns the total number of combinations for selecting r item out of n items.

$$n\mathrm{C}r = \frac{n!}{r!(n-r)!}$$

Example: How many different groups of 7 students can be formed with 15 students?

15 [MATH] **Probability ➔** *n***C***r* 7 [ENTER]

```
15C7
                  6 435
```

! Returns a factorial.

Example: Calculate 6 × 5 × 4 × 3 × 2 × 1.

6 [MATH] **Probability ➔ !** [ENTER]

```
6!
                                    720
```

Complex

In order to use the sub-menu items within the Complex menu, the calculator must be set up to handle complex numbers. Otherwise the result will be a data type error (09). Refer to section "SET UP Menu" in this chapter for changing/verifying the calculator's **setup to enable complex number answers**, in either rectangular or polar coordinates.

conj(**conj(*complex number*)**

Returns the complex conjugate of the specified complex number.

```
conj(5 + 2i)
                                    5 – 2i
                                RAD    CPLX
```

real(**real(*complex number*)**
Returns the real part of a complex number.

```
real(5 + 2i)
                                  5
                        RAD    CPLX
```

mage(**image(*complex number*)**
Returns the imaginary part of a complex number.

```
image(5 + 2i)
                                  2
                        RAD    CPLX
```

abs(**abs(*complex number*)**
Returns the absolute value of a complex number.

```
abs(5 + 2i)
                 5.3851648071345040313
                        RAD    CPLX
```

arg(**arg(*complex number*)**
Takes the coordinates ($x + y$i), and returns the θ.

```
arg(5 + 2i)
                 0.3805063771123648863
                        RAD    CPLX
```

AER (Algebraic Expression Reserve)

The Algebraic Expression Reserve (AER) is convenient for repetitive calculations. Calculations using algebraic expressions can be defined and recalled here. See next chapter for an explanation.

4. AER (Algebraic Expression Reserve)

The calculator allows to define and recall user defined algebraic expressions with varying parameters.

Creating a New AER Definition

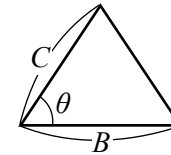
To define a new expression select the sub-menu item AER in the MATH menu. If there are already expressions defined they will appear in the AER list. To create a new expression press the "**+**" sign at the end of the list. The calculator now switches to the AER definition mode:

(1) Entry of the name
For each expression a unique name must be entered. This name has to start with a character and may have at least 8 characters or digits. This name will be used to represent the assigned expression like the name of a function.

(2) Entry of the parameters and the expression in the following format:
f* (*parameter* ; *parameter* ; ...) = *expression
For *parameter* the global variables ($A - Z$ and θ) can be used. They have to be entered after the f between the parenthesis. Multiple parameters must be separated by semicolons ([2nd F] [;]). The expression itself will be entered after the equals sign.

(3) Press Save oder [ENTER] to save the expression.

Example: Enter the formula for the area of triangles.



Area $S = \dfrac{B \cdot C \cdot \sin\theta}{2}$

MATH **AER** → +

| Name
$f(\ ) =$
Abort Save

Entry of the name via keyboard:

Area ↵

Area
$f(\ ) =$
Abort Save

Entry of the parameters θ, B and C:

[ALPHA] [θ] [2nd F] [;] [ALPHA] [B] [2nd F] [;] [ALPHA] [C]

Area

$f(\theta; B; C) =$

Abort Save

Entry of the formula for the area:
Move the cursor to the right of the "=" symbol using the cursor key ▶.

[ALPHA] [B] [ALPHA] [C] [sin] [ALPHA] [θ] [÷] 2

Area

$f(\theta; B; C) = B\ C \sin \theta \div 2$

Abort Save

Press Save to store the definition of the expression.

Recalling Expressions

To recall a stored expression select the sub-menu entry AER in the MATH menu. A list of all existing AER definitions will be shown. Tap on the desired AER definition in the list to recall it. This enters the name of the AER definition at the cursor position on the calculator display.

An AER definition can be calculated in two ways:

(1) Interactive
In this case the parameters needed to calculate the expression will be requested individually. After entering the values for all parameters the expression will be calculated and the result is shown.

(2) As function call within a calculation
In this case the values for the parameters have to be given in parenthesis following the function name. Multiple parameters have to be separated by semicolons.

Example: Interactive calculation with the above created AER definition “Area”.

MATH AER → Area

Area

ENTER

```
Area
θ ⇐ |
```

Entry of the value of the angle θ.

30

```
Area
θ ⇐ 30|
```

ENTER

```
Area
θ ⇐ 30
B ⇐
```

Entry of the value of the side lenght B.

100 **ENTER**

```
Area
θ ⇐ 30
B ⇐ 100
C ⇐
```

Entry of the value of the side lenght C.

20 **ENTER**

```
Area
θ ⇐ 30
B ⇐ 100
C ⇐ 20
                    500
```

The area of the triangle is 500.

By pressing the **ENTER** key immediately after the result is displayed, the same expression can be calculated again with different values for the parameters.

If no value is given for a requested parameter (the **ENTER** key is pressed immediately) then the last used value for this parameter will be used.

Example: Calculate the area of a triangle with the angle θ = 30° and the side lengths B = 50 and C = 10 by using the previously created AER definition “Area” as a function. The values for the parameters have to be given in the same order as they are specified during the definition.

[MATH] AER → Area

Area

[(] 30 [2nd F] [;] 50 [2nd F] [;] 10 [)]

Area(30; 50; 10)

[ENTER]

Area(30; 50; 10) 125

The area of the triangle is 125.
AER functions can also be used within a calculation expression.

Example:

40 Area(30; 50; 10) + 2,5 5 002,5

Correcting and Deleting AER Definitions

To correct or delete an existing AER definition select the sub-menu AER in the MATH menu. A list with all saved expressions will be displayed.
Switch the list into editig mode by pressing Edit in the list header.

Correcting an AER Definition

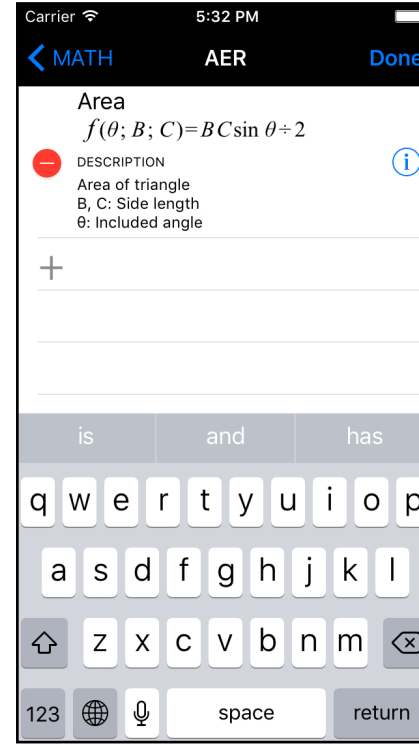
Tap on the entry that should be modified. The calculator now switches to the AER definition mode. Now, name, parameters and expression can be edited. To save the changes press Save. By pressing Abort the changes will be dismissed.

Adding an Explanation to an AER Definition

By tapping the ⓘ sign of a list entry a multi-line comment text can be assigned to an AER definition and an existing comment will be displayed.

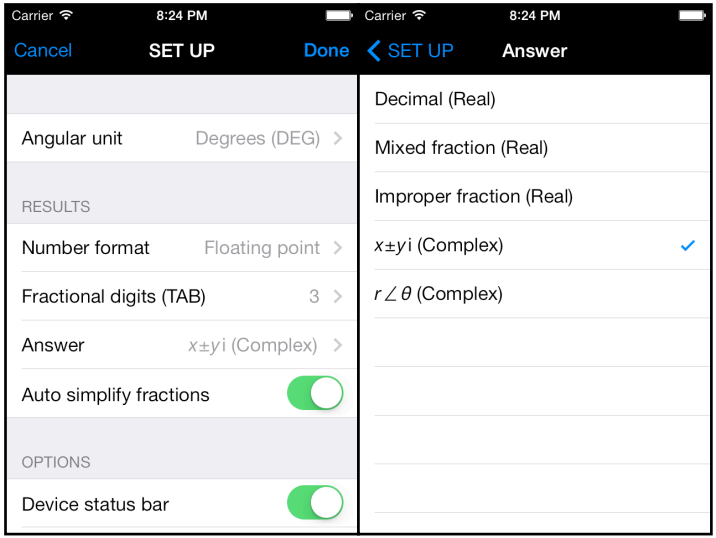
Deleting an AER Definition

By tapping the ⊖ sign of a list entry the corresponding AER definition can be deleted.



3. Calculations Using Complex Numbers

To calculate using complex numbers, select the sub-menu item $x \pm y\mathrm{i}$ or $r\angle\theta$ in the **Answer** of the **SET UP** menu (the designation "CPLX" will be shown below the display). Complex numbers can be noted using either $x \pm y\mathrm{i}$ (rectangular coordinates) or $r\angle\theta$ (polar coordinates). The setting of the **Answer** in the **SET UP** menu determines which notation is used for the result of a complex calculation. Complex numbers can be entered in either notation independent of this setting by using the keys [2nd F] [i] or [2nd F] [∠]. Please note, that when using polar coordinates the angle θ is interpreted based on the selected angular unit (DEG, RAD, GRAD).



Examples: Calculate (3 + 4i) × (4 – 6i)

[(] 3 [+] 5 [2nd F] [i] [)] [×] [(] 4 [–] 6 [2nd F] [i] [)] [ENTER]

Calculate: (15 ∠ 0,785) + (4 – 6i)

[(] 15 [∠] 0.785 [)] [+] [(] 4 [–] 6 [2nd F] [i] [)] [ENTER]

(3 + 5**i**) × (4 – 6**i**)

42 + 2**i**

(15 ∠ 0.785) + (4 – 6**i**)

14.610824037507996444
+ 4.6023777165804888562i

RAD CPLX

Functions available for complex number calculations

The following function keys are available for complex number calculations without the limits existing in real number calculations:

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

The following MATH menu functions are also available for complex number calculations:

$\log_2$, 2^x, sec, csc, cot, $\sec^{-1}$, $\csc^{-1}$, $\cot^{-1}$, sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$, abs(, round(, ipart, fpart, int, min, max, conj(, real(, image(, abs(, arg(

4. Calculations Using Physical Constants CONST

The Calculator offers 47 physical constants, that can be used in calculations. To enter a constant to an expression press [2nd F] [CONST]. This shows the constant selection list. By tapping on one entry in this list, the corresponding constant symbol will be added to the current expression.
See appendix „Physical Constants“ for an overview of the available physical constants.

Example: An object drops in free fall for 8 seconds. What is the final speed of the Object?

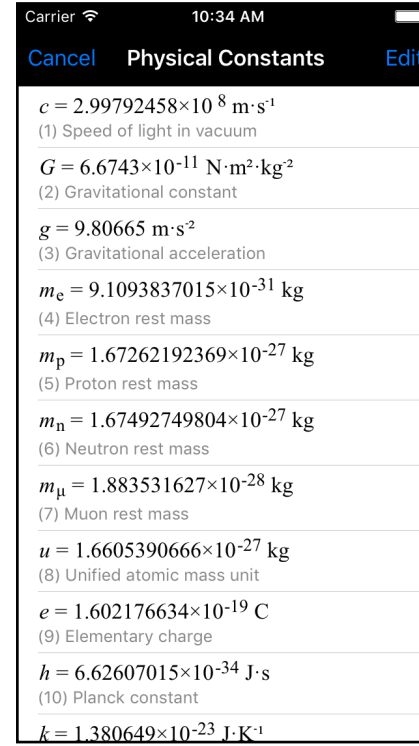
Formula: $v = g \times t$

Enter: [2nd F] [CONST] g [×] 8 [ENTER]

Display: $g \times 8$

78.4532

Result: 78.4532 m/s



CHAPTER 3
SCIENTIFIC MODE

In this mode iPhone, iPod touch or iPad can be used like a traditional scientific calculator with 20 digits. It operates with sequential algebraic input, so that calculations will be performed during entry.

Calculations

Now we will perform some simple calculations. Press the following keys and look at the display:

Enter	Display
123	123.
+	123.
654	654.
=	777.

Did you get the correct answer? If you didn't, press the red [C·CE] key, and try the same calculation again.
Now call up the value of pi (π).
The symbol "π" is printed in orange above the [EXP] key. The functions identified by orange letters can be used by first pressing the orange [2nd F] key in the upper left of the calculator, and then pressing the required function key. When the [2nd F] key is pressed, the designation "2nd F" will appear in the upper part of the display.

In this manual, we will always show the key´s second function as follows:
[2nd F] [EXP] (π) → [2nd F] [π]

Enter	Display
[2nd F] [π]	3.1415926535897932385

What you see on the display is the value of π.

Next, compute 10^4. For this calculation, you should use the function 10^x. This function is also identified in orange, so the [2nd F] key must be pressed.

Enter	Display
4 [2nd F] [10^x]	10 000. (10^4 = 10000.)

An Outline of Some of the Major Key Functions

✳ [C·CE] (clear) (red key)

If this key is pressed immediately after numeric data is entered or the content of the memory is recalled, only that data will be cleared. In any other case, operation of the [C·CE] key will clear all the operators and/or numeric data that have been entered. The content of the memory is not cleared with the [C·CE] key operation.

Enter	Display
123 [+] 456	456.
[C·CE]	0.
789 [=]	912. (123 + 789 = 912)
6 [×] 2 [+]	12.
[C·CE]	0.
6 [÷] 2 [+]	3.
5 [=]	8.

The [C·CE] key may also be used to clear an error.

Enter	Display
	Error symbol
5 [÷] 0 [=]	E 0.
[C·CE]	0.

✳ [FSE] (display mode switch)

This key is used to switch the display mode for the result of a calculation from the floating point decimal system (normal mode) to fixed point decimal (FIX), scientific notation (SCI), or engineering notation (ENG) system, or vice versa.

Enter	Display
[2nd F] [CA]	
23 [×] 1 000 [=]	**23 000.** (Normal)
[FSE]	FIX **23 000.000** (FIX)
[FSE]	SCI **2.300** ^{04} (SCI)
[FSE]	ENG **23.000** ^{03} (ENG)

✳ [TAB] (specifies the number of decimal places)

This key is used to specify the number of decimal places when used in conjunction with a numeral key. Press the clear key [C·CE] so that “0.” is displayed. Press the key [FSE] until the display will show “0.000” (FIX mode).

1. Specify 2 decimal places.

Enter	Display
[2nd F] [TAB] 2	FIX **0.00**
5 [÷] 8 [=]	FIX **0.63**

2. Specify 5 decimal places.

Enter	Display
[2nd F] [TAB] 5	FIX **0.62500**

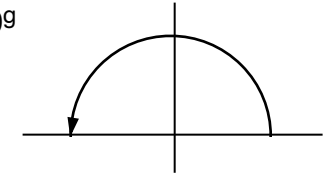
✳ [CA] (clear all)

The [2nd F] [CA] key will clear the operators and/or numeric data that have been entered and also resets the TAB setting to 3 and the display mode to floating point decimal.

✳ [DRG] (specifies angular unit)

This key is used to specify the angular units for numeric data used in trigonometric functions, inverse trigonometric functions, or coordinates conversion.

$180° = \pi$ (rad) = 200^g



DEG:	Degree	[°]
RAD:	Radian	[rad]
GRAD:	Grad	[g]

Enter	Display
	DEG (Degrees)
DRG	RAD (Radians)
DRG	GRAD (Grads)
DRG	DEG (Degrees)

✳ [DRG►] (transforms between angular modes)

This key is used for transformations between angular modes and simultaneously specifies the angular mode for numerical data for trigonometric functions, inverse trigonometric functions and coordinate transformations.

Enter	Display
[2nd F] [CA] 180	DEG **180.** (Degrees)
[2nd F] [DRG►]	RAD **3.1415926535897932385** (Radians)
[2nd F] [DRG►]	GRAD **200.** (Grads)
[2nd F] [DRG►]	DEG **180.** (Degrees)

✳ [0] to [9], [•], [EXP] and [+/–]

[EXP]: Used to enter a number in exponential form. The exponent will be displayed superscript with smaller digits.

Enter	Display
[C·CE] 4 [EXP] 3	$4.^{03}$ (4×10^3)
[=]	4 000.
[+/–]	–4 000.

[+/–]: Used to enter a negative number (or to reverse the sign from negative to positive).

Enter	Display
1.23 [+/–]	–1.23
[EXP] 5 [+/–]	-1.23^{-05}
[=]	–0.0000123
[+/–]	0.0000123

✳ [→] (backspace)

With this key the last entered digit can be deleted.

Enter	Display
125	125.
[→]	12.
3	123.
[+] 478	478.
[→]	47.
[→]	4.
56	456.
[=]	579. (123 + 456 = 579)

Enter	Display
1.456 [EXP] 19	1.456^{19}
[→]	1.456^{01}
2	1.456^{12}
[÷] 1000 [=]	1 456 000 000. (1.456×10^{12} / 1000 = 1 456 000 000)

Basic Operations

1. Addition, Subtraction

Enter the following:
12 [+] 45.6 [−] 32.1 [+] 789 [−] 741 [+] 213 [=]
Answer: 286.5

2. Multiplication, Division

a) Enter the following: 841 [×] 586 [÷] 12 [=]
Answer: 41 068.833333333333333
b) Enter the following: 427 [+] 54 [×] 32 [÷] 7 [−] 39 [×] 2 [=]
Answer: 595.85714285714285714

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

Constant Multiplication: The first number entered is a constant.

Enter: 3 [×] 5 [=] Answer: 15
Enter: 10 [=] Answer: 30

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

Enter: 15 [÷] 3 [=] Answer: 5

Enter: 30 [=] Answer: 10

Note:

The computer places some calculations in pending status depending on their priority levels. Accordingly, in successive calculations the operator and numerical value of the calculation last performed in the computer are handled as a calculation instruction and a constant for the next calculation, respectively.

$a \underline{+ b \times c} =$	$+ bc$	(Constant addition)
$a + b \underline{\div c} =$	$\div c$	(Constant division)
$\underline{a \div b \times} c =$	$\frac{a}{b} \times$	(Constant multiplication)
$a \times b \underline{- c} =$	$- c$	(Constant subtraction)

3. Memory Calculations

The first independent memory can be accessed using the [x→M1], [RM1], [M1+] keys and the second independent memory by using the [2nd F] [x→M2], [2nd F] [RM2] and [2nd F] [M2+] keys.

Before starting a calculation, clear the memory by pressing [C·CE] and [x→M1].
If a value other then 0 is stored into the memory, "M1" and/or "M2" will be displayed.

Enter: 12 [+] 5 [M1+]

Answer: 17

To subtract, key in: 2 [+] 5 [=] [+/–] [M1+]

Answer to this equation: –7

Enter [RM1] to recall memory: 10 is displayed.

Enter: 12 [×] 2 [=] [x→M1]

Answer: 24 (Replaces 10 in memory)

Enter: 8 [÷] 2 [M1+]

Answer: 4 [RM1]: 28

To subtract a number from the memory, press the [+/–] and [M1+] keys.

Besides the two independent memories which can be modified with [x→M1] and [2nd F] [x→M2] there are 10 memory slots available which can be modified with [STO] [0] to [STO] [9].

To read the contents of these memories, press the [2nd F] [RCL] [0] to [2nd F] [RCL] [9] keys.

In D.A.L. mode you can access these memories by the variable assigned to the corresponding number key. See section “Using Memories” in chapter 2: “DIRECT ALGEBRAIC LOGIC (D.A.L.)”

Scientific Calculations

To perform trigonometric or inverse trigonometric functions, and coordinates conversion, designate the angular unit for the calculations. The angular unit DEG, RAD, GRAD is specified using the [DRG] key.

1. Trigonometric Functions

Set the angular unit to DEG.
Calculate: sin 30° + cos 40° =
Enter the following: 30 [sin] + 40 [cos] [=]
Answer: 1.2660444431189780352
Calculate: cos 0.25π
Set the angular unit to RAD.
Enter: 0.25 [×] [2nd F] [π] [=] [cos]
Answer: 0.7071067811865475244

2. Inverse Trigonometric Functions

Calculate: $\sin^{-1} 0.5$
Set the angular unit to DEG.
Enter: 0.5 [2nd F] [$\sin^{-1}$] Answer: 30

Calculate: $\cos^{-1} -1$
Set the angular unit to RAD.
Enter: 1 [+/−] [2nd F] [cos⁻¹]

Answer: 3.1415926535897932385 (value of π)
(To enter a negative number, press the [+/−] key after the number.)

The calculation results of the respective inverse trigonometric function will be displayed within the following limits:

$\theta = \sin^{-1} x$, $\theta = \tan^{-1} x$	$\theta = \cos^{-1} x$
DEG: $-90 \leq \theta \leq 90$ [°]	DEG: $0 \leq \theta \leq 180$ [°]
RAD: $-\pi/2 \leq \theta \leq \pi/2$ [rad]	RAD: $0 \leq \theta \leq \pi$ [rad]
GRAD: $-100 \leq \theta \leq 100$ [g]	GRAD: $0 \leq \theta \leq 200$ [g]

3. Hyperbolic and Inverse Hyperbolic Functions

Calculate: sinh 4
Enter: 4 [hyp] [sin] Answer: 27.289917197127752449
Calculate: $\sinh^{-1} 9$
Enter: 9 [2nd F] [archyp] [sin] Answer: 2.8934439858858713781

4. Power Functions

Calculate: 20^2

Enter: 20 [x^2] Answer: 400

Calculate: 3^3 and 3^4

Enter: 3 [y^x] 3 [=] Answer: 27

Enter: 3 [y^x] 4 [=] Answer: 81

5. Roots

Calculate: $\sqrt{25}$

Enter: 25 [$\sqrt{\ }$] Answer: 5

Calculate: Cubic root of 27

Enter: 27 [2nd F] [$\sqrt[3]{\ }$] Answer: 3

Calculate: Fourth root of 81

Enter: 81 [2nd F] [$\sqrt[x]{y}$] 4 [=] Answer: 3

6. Logarithmic Functions

Calculate: ln 21, log 173

Natural Logarithms:

Enter: 21 [ln] Answer: 3.0445224377234229965

Common Logarithms:
Enter: 173 [log] Answer: 2.2380461031287954146

7. Exponential Functions

Calculate: $e^{3.0445}$
Enter: 3.0445 [2nd F] [e^x]
Answer: 20.999528813094317577 (21 as in Natural Logarithms above)
Calculate: $10^{2.238}$
Enter: 2.238 [2nd F] [10^x]
Answer: 172.98163592151015219 (173 as in Common Logarithms above)

8. Reciprocals

Calculate: 1/6 + 1/7
Enter: 6 [2nd F] [$1/x$] [+] 7 [2nd F] [$1/x$] [=]
Answer: 0.3095238095238095238

9. Factorial

Calculate: 69!

Enter: 69 [2nd F] [$n!$]

Answer: $1.7112245242814131137^{98}$ ($=1.7112245242814131137\times10^{98}$)

On calculating the factorial it is easily possible to overflow the calculation limits of the calculator which results in the error indication "**E**". Note that the section on "Calculation Range" in the appendixes deals with calculation limits of the calculator.

10. Permutations

Formula:

$$_n\mathrm{P}_r = \frac{n!}{(n-r)!}$$

Example:

From a group of 10 persons, you must decide how many combinations of 3 persons can be lined up. What is the total number of ways different groups of 3 can be arranged?

Enter: 10 [2nd F] [nPr] 3 [=] Answer: 720

11. Combinations

Formula:

$$_nC_r = \frac{n!}{r!(n-r)!}$$

Example:

You must select 3 persons from a group of 10. How many different combinations of 3 persons can be formed?

Enter: 10 [nCr] 3 [=] Answer: 120

12. Percentage Calculations

Calculate: 45% of 2,780 $\left(2{,}780 \times \frac{45}{100}\right)$

Enter: 2780 [×] 45 [2nd F] [%] [=]

Answer: 1 251

Calculate: $200 - 200 \times \frac{30}{100}$

Enter: 200 [−] 30 [2nd F] [%] [=]

Answer: 140

13. Angle/Time Conversions

To convert an angle given in the sexagesimal system (degrees/minutes/seconds) to its decimal equivalent, a value in degrees must be entered as an integer and values in minutes and seconds as decimal fractions, respectively.
Convert 12°47′52″ to its decimal equivalent.
Enter: 12.4752 [→DEG]
Answer: 12.797777777777777778

When converting an angle in decimal degrees to its sexagesimal equivalent (degrees/minutes/seconds), the answer is broken down:
integer part = degrees;
1st and 2nd decimal digits = minutes;
3rd and 4th digits = seconds;
and the 5th digit and up = fractions of seconds.

Convert 24.7256 to its sexagesimal equivalent (degrees/minutes/seconds)
Enter: 24.7256 [2nd F] [→D.MS]
Answer: 24.433216 or 24°43′32″

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

Enter: 0.0225 [→DEG] [+] 0.0238 [→DEG] [+] 0.0222 [→DEG] [=]

Answer 1: 0.1236111111111111111

Enter: [÷] 3 [=]

Answer 2: 0.04120370370370370370

Enter: [2nd F] [→D.MS]

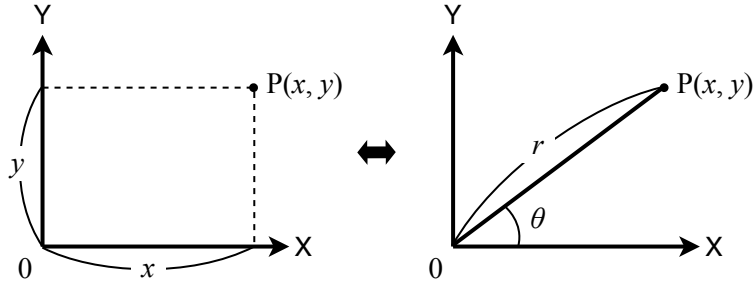
Answer 3: 0.02283333333333333333

or the average time is 2 minutes 28 seconds.

Note: Consider using the "Time and Frames Calculator" in "UNITS MODE" for time calculations.

14. Coordinate Conversion

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



$r = \sqrt{x^2 + y^2}$ DEG: $0 \leq |\theta| \leq 180$

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

$\theta = \tan^{-1}\dfrac{y}{x}$ GRAD: $0 \leq |\theta| \leq 200$

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

Angular unit: DEG

Enter: 6 [a] 4 [b] [2nd F] [→rθ] Answer: 7.2111025509279785862 (r)

Enter: [b] Answer: 33.690067525979786914 (θ)

Calculate the magnitude and direction (phase) of vector i = 12 + j9

Enter: 12 [a] 9 [b] [2nd F] [→rθ] Answer: 15 (r)

Enter: [b] Answer: 36.869897645844021297 (θ)

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

Solve for P(14, π/3), r =14, θ = π/3

Angular unit: RAD

Enter: [2nd F] [π] [÷] 3 [=] [b] 14 [a] [2nd F] [→xy]

Answer: 7 (x)

Enter: [b]

Answer: 12.124355652982141055 (y)

15. Using Physical Constants

The calculator offers 47 physical constants, which can be used in calculations. To insert the value of a constant press the [CONST] key. A list appears, where the desired constant can be selected.

Example:

An object drops in free fall for 8 seconds. What is the final speed of the Object? Formula: $v = g \times t$

Enter: [CONST] g [×] 8 [=]

Answer: 78,4532 m/s

Use of Parentheses

The parentheses keys are needed to cluster together a series of operations when it is necessary to override the priority system of algebra. When parentheses are in use in the calculator, “( )” will be displayed. Calculations in parentheses have priority over other calculations. The parentheses can be nested more than once. The calculations within the innermost set of parenthesis will be performed first.

Calculate: 12 + 42 ÷ (8 – 6)
Enter: 12 [+] 42 [÷] [(] 8 [–] 6 [)] [=]
Answer: 33

Calculate: 126 ÷ {(3 + 4) × (3 – 1)}
Enter: 126 [÷] [(] [(] 3 [+] 4 [)] [×] [(] 3 [–] 1 [)] [)] [=]
Answer: 9

Note:
The [)] key operation located just before a [=] or [M1+] or [2nd F] [M2+] key operation can be omitted.

Decimal Places

The [2nd F] and [TAB] keys are used to specify the number of decimal places in the calculation result. The number of decimal places after the decimal point is specified by a numeral key ([0] to [9]) pressed after the [2nd F] and [TAB] keys. In this case, the display mode must be fixed decimal point (FIX), scientific notation (SCI), or engineer notation (ENG).

[2nd F] [TAB] [0] → Designates 0 decimal places.
(The number is rounded to the nearest integer.)

[2nd F] [TAB] [1] → Designates 1 decimal places.
(The number is rounded to 1 decimal place.)

[2nd F] [TAB] [9] → Designates 9 decimal places.
(The number is rounded to 9 decimal places.)

To clear the TAB setting (switching to a variable number of decimal digits after the decimal point) use [2nd F] [TAB] [•] in scientific (SCI) or engineering (ENG) notation. When [2nd F] [TAB] [•] is pressed while the fixed point system is active (FIX) then the calculator switches back to floating point decimal system (normal mode). To reset the TAB settings, and display mode to factory settings press [2nd F] [CA]. (Sets TAB to 3 decimal places and the display mode to floating point decimal.)

Example:

[2nd F] [CA] [FSE]	→ 0.000	(FIX mode)
[2nd F] [TAB] [9]	→ 0.000000000	(FIX mode)
0.5 [÷] 9 [=]	→ 0.055555556	(FIX mode)
	(The number is rounded to 9 decimal places.)	
[FSE]	→ 5.555555556^{-02}	(SCI mode)
	(The mantissa is rounded to 9 decimal places.)	
[2nd F] [TAB] [•]	→ $5.5555555555555555556^{-02}$	(SCI mode)
	(All available decimal places are displayed.)	
[2nd F] [TAB] [3]	→ 5.556^{-02}	(SCI mode)
	(The mantissa is rounded to 3 decimal places.)	
[FSE]	→ 55.556^{-03}	(ENG mode)
[FSE]	→ 0.0555555555555555555	

This is held by the calculator in the form of $5.55555555555555555555 \times 10^{-2}$. Rounding the 21th digit of the mantissa results in $5.5555555555555555556 \times 10^{-2}$. When the display mode is changed to the floating decimal point mode, the rounded part may not be displayed as shown in this example.

Modify Function

In this calculator, all calculation results are internally obtained in scientific notation with up to 22 digits for the mantissa. However, since calculation results are displayed in the form designated by the display mode (FIX, SCI or ENG) and the number of decimal places set by TAB, the internal calculation result may differ from that shown on the display.

By using the modify function [2nd F] [MDF], the internal value is converted to match that of the display, so that the displayed value can be used without change in subsequent operations.

This function is very useful when you must perform calculations where the significant digits of a number are important.

Example 1:
To solve 5 ÷ 9 = and then multiply the calculation result by 9.

[FSE] (To display the FIX indicator)
[2nd F] [TAB] [1] (To fix the number of decimal positions to 1)

• Normal calculation:

Enter	Display
5 [÷] 9 [=]	0.6
[×] 9 [=]	5.0

Note: The calculator stores 0.5555555555555555555556 as internal result of 5 ÷ 9 and displays it as 0.6.
The internal result will be multiplied by 9 and gives 5.0 (the first entered value).

• Calculation with modify function:

Enter	Display
5 [÷] 9 [=] [2nd F] [MDF]	0.6
[×] 9 [=]	5.4

Note: The modify function replaces the internally stored result with the displayed one (0.6).
The calculator multiplies 0.6 with 9; the result is 5.4.

Example 2:
Multiply the result of (18 ÷ 7 =) by 5 and then double it.

[2nd F] [TAB] [3] (To fix the number of decimal positions to 3)

• Normal calculation:

Enter	Display
18 [÷] 7 [=]	2.571
[×] 5 [×] 2 [=]	25.714

• Calculation with modify function:

Enter	Display
18 [÷] 7 [=] [2nd F] [MDF]	2.571
[×] 5 [×] 2 [=]	25.710

Priority Levels

The calculator is provided with a function that decides the priority levels of individual calculations, which permits keys to be operated according to a given mathematical formula. The following shows the priority levels of individual calculations.

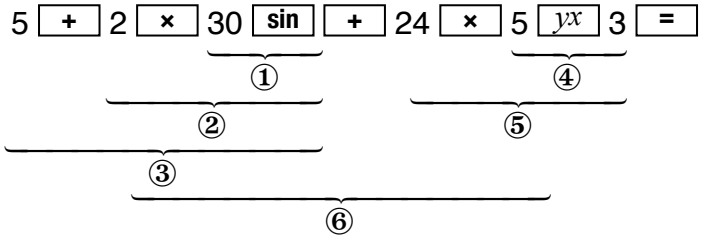
1. Priority Level of Operations

1. Functions such as sin, x^2, %
2. y^x, $\sqrt[x]{y}$
3. ×, ÷
4. +, –
5. =, M1+, M2+

(Calculations which are given the same priority level are executed in their sequence of input.)

Example:

Key operation and sequence of calculations in 5 + 2 × sin 30 + 24 × 53 =



The numbers ① – ⑥ indicate the sequence in which the calculations are carried out. When calculations with higher priority are executed, those with lower priority must be saved in the meantime. The calculator is provided with a memory area for up to 30 pending operations.

As the memory area is also used for calculations with parentheses, calculations can be performed according to a given mathematical formula unless parentheses and pending operations exceed 30 levels in total.

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

2. Calculation without Parentheses

Example:

1 [+] 2 [=] — 1 pending calculation

①

1 [+] 2 [×] 3 [=] — 2 pending calculations

① ②

1 [+] 2 [×] 3 [yx] 4 [=] — 3 pending calculations

① ② ③

1 [+] 2 [×] 3 [yx] 4 [÷] 5 — After [yx] is pressed, 3 calculations remain pending. Pressing the [÷] key executes the calculation of "y^x" highest in priority level and "×" identical in priority level. After [÷] is pressed, the other 2 calculations remain pending.

① ② ③

②

3. Calculation using Parentheses

Example:

i) 1 [+] 2 [×] 3 [y^x] [(] 4 numerals and calculations are left pending.

① ② ③

4 [÷] 5

④

ii) 1 [+] 2 [×] [(] 3 [−] Pressing the [)] key executes the calculation of 3 – 4 ÷ 5 in the parentheses, leaving 2 calculations pending.

① ② ③

4 [÷] 5 [)]

④

②

Calculations with Complex Numbers

In scientific mode the calculator can be configured to calculate with complex numbers. For this press [2nd F] [CPLX] so that the indication „CPLX“ is shown on the display. Press this keys combination again to switch back to real numbers (the indication „CPLX“ disappears from the display).

Note: When switching between complex and real numbers this also affects the D.A.L. mode, this means that both calculator modes always share the same number format and calculation mode.

Complex numbers can be entered and displayed using two notations:

- $x \pm y\mathrm{i}$ (rectangular coordinates): selected by pressing [2nd F] [$\rightarrow xy$].
- $r\angle\theta$ (polar coordinates): selected by pressing [2nd F] [$\rightarrow r\theta$].

In rectangular coordinates notation the calculator displays the real part ($\Re$) in the first display line and the imaginary part ($\Im$) in the second display line. The key [$\Re$] is used to specify the real part during entry and the key [$\Im$] to specify the imaginary part. For this first enter the number for the real or imaginary part and then press the [$\Re$] or [$\Im$] keys respectively.

In polar coordinates notation the calculator displays the radius r in the first display line and the angle θ in the second display line. For entering use the keys [r] and [θ]. Note, that the selected angular mode (DEG, RAD , GRAD) affects the interpretation of the angle .

Example:
Calculate (5,34 + 12,7i) × (0 – 8,2i)

Enter	Display
[2nd F] [CPLX] [2nd F] [$\rightarrow xy$]	DEG CPLX 0. 0. i
5.34 [$\Re$]	DEG CPLX 5.34 0. i
12.7	DEG CPLX 5.34 12.7 i

Enter	Display
[×] 8.2 [+/−]	DEG CPLX –8.2 0. i
[ℑ]	DEG CPLX 0. 8.2 i
[=]	DEG CPLX 104.14, –43.788 i

Display the last result using polar notation with θ in radians:
Press [DRG] until indication RAD is displayed.

[2nd F] [→rθ]	RAD CPLX 112.97136160992306992 r –0.3980295226727533915 θ

Functions available for complex number calculations

Additionally to the basic arithmetical operations, the following function keys can be used with complex numbers:

- Trigonometric functions [sin], [cos], [tan], [sin⁻¹], [cos⁻¹], [tan⁻¹]
- Hyperbolic and inverse hyperbolic functions ([hyp] [sin], [2nd F] [archyp] [sin] etc.)
- Logarithms [ln], [log] and exponential functions [e^x], [10^x]
- Power functions and roots [y^x], [$\sqrt[x]{y}$], [x^2], [$\sqrt[3]{\ }$]
- Reciprocals [$1/x$]
- Modify function [MDF]
- Memory calculations

If a function key is pressed, that is not supported in complex mode, the calculator will be set to error condition „E“. Press [C·CE] to clear the error.

If a complex number is stored in a memory and the memory contents is retrieved while the calculator is not in CPLX mode, only the real part $\Re$ of the stored number will be read.

For further operations with complex numbers see section “Calculations Using Complex Numbers” in chapter 1: “DIRECT ALGEBRAIC LOGIC (D.A.L.)”.

CHAPTER 4
UNITS MODE

The units mode offers easy conversions between different units and calculations with mixed units. The conversion factors and unit symbols can be freely defined by the user. The calculator is shipped with 84 physical units and 16 SI prefixes predefined. Further the units mode also supports currency conversions based on exchange rates which will be automatically updated from the internet. The units mode also supports calculating with time values and with frame rates.

Note:
You should first read the sections “Calculations”, “An Outline of Some of the Major Key Functions” and “Basic Operations” in the chapter 3 “SCIENTIFIC MODE”, to get familiar with the operation of the calculator and its basic functions before you use the units mode.

Predefined Units

The units mode offers 13 unit sets each with possibly 24 units. Ten of the unit sets are predefined by default. The first unit set is a specialized time and frame rate calculator, the second one is predefined with currency units and the remaining with physical units.
Only one of the unit sets can be active at the same time. The active unit set determines which units are assigned to the unit keys.
The following tables show all predefined unit sets and their units:

Unit Set	Unit	Symbol	Category	Factor	Off-
TIME AND FRAMES CALC.	Days	D	Time calculator	1/24	0
	Hours	**h**		**1**	
	Minutes	m		60	
	Seconds	s		3600	
	Frames	f		(last used frame rate)	
	24 frames per second	24 f/s		86400	
	25 frames per second	25 f/s		90000	
	29.97 non drop frames	29.97		107892	
	29.97 drop frames	29.97 df		107892	
	30 frames per second	30 f/s		108000	
	50 frames per second	50 f/s		180000	
	59.94 non drop frames	59.94		215784	
	59.94 drop frames	59.94 df		215784	
	60 frames per second	60 f/s		216000	

Unit Set	Unit	Symbol	Category	Factor	Off-
CURRENCY	**Euro**	**€**	Currency	**1**	0
	Pound Sterling	£		0.956*	
	Swedish Krona	SEK		10.6781*	
	Swiss Franc	CHF		1.4914*	
	Croatian Kuna	HRK		7.2702*	
	Hungarian Forint	HUF		263.591*	
	Zloty	PLN		4.1486*	
	Ruble	RUB		39.7447*	
	United States Dollar	US$		1.3972*	
	Canadian Dollar	CA$		1.7025*	
	Australian Dollar	AU$		1.9877*	
	Yen	¥		126.7095*	
	Hong Kong Dollar	HK$		10.8291*	

* The exchange rates will be updated daily from European Central Bank if an internet connection exists.

Unit Set	Unit	Symbol	Category	Factor	Off-
LENGTH	micrometer	μm	Length	1×10^{6}	0
	millimeter	mm		1000	
	centimeter	cm		100	
	decimeter	dm		10	
	meter	**m**		**1**	
	kilometer	km		1×10^{-3}	
	mil	mil		$1/2.54\times10^{-5}$	
	inch (international)	in		$1/2.54\times10^{-2}$	
	foot (international)	ft		$1/3.048\times10^{-1}$	
	yard (international)	yd		$1/9.144\times10^{-1}$	
	mile (international)	mil		1/1609.344	
	mile (nautical)	nmi		1/1852.0	
	astronomical unit	au		1/149597870691	

Unit Set	Unit	Symbol	Category	Factor	Off-
AREA	square millimeter	mm^2	Area	1×10^6	0
	square centimeter	cm^2		1×10^4	
	square meter	**m^2**		**1**	
	are	a		1×10^{-2}	
	hectare	ha		1×10^{-4}	
	square kilometer	km^2		1×10^{-6}	
	square inch	in^2		$1/6.4516\times10^{-4}$	
	square foot (inter.)	ft^2		$1/9.290304\times10^{-2}$	
	square yard	yd^2		$1/8.3612736\times10^{-1}$	
	acre (Morgen)	acre		1/4046.8564224	
	Joch (Austria)	Joch		1/5754.642	
	square mile (international)	mi^2		$1/1609.344^2$	

Unit Set	Unit	Symbol	Category	Factor	Off-
VOLUME	cubic centimeter	cm^2	Volume	1×10^3	0
	liter	**l**		**1**	
	cubic meter	m^3		1×10^{-3}	
	teaspoon (US)	tsp		768/3.785411784	
	tablespoon (US)	tbsp		256/3.785411784	
	cubic inch	in^3		231/3.785411784	
	fluid ounce (US)	oz		128/3.785411784	
	cup	cu		16/3.785411784	
	pint, liquid (US)	pt		8/3.785411784	
	quart, liquid (US)	qt		4/3.785411784	
	gallon, liquid (US)	gal		1/3.785411784	
	cubic foot	ft^3		231/(1728×3.785411784)	

Unit Set	Unit	Symbol	Category	Factor	Off-
MASS	milligram	mg	Mass	1×10^{6}	0
	carat	ct		5×10^{3}	
	gram	g		1×10^{3}	
	kilogram	**kg**		**1**	
	metric ton	t		1×10^{-3}	
	grain	gr		7000×0.45359237	
	ounce (avoirdupois)	oz		16/0.45359237	
	ounce (troy)	ozt		32.15074625	
	pound (troy)	lbt		1/0.3732417216	
	pound (avoirdupois)	lb		1/0.45359237	
	short ton (US, 2000 lb)	tn		1/(0.45359237×2000)	
	long ton (UK,2240 lb)	l.tn		1/(0.45359237×2240)	

Unit Set	Unit	Symbol	Category	Factor	Offset
POWER / ENERGY	**watt**	**W**	Power	**1**	0
	metric horsepower	hp		1/735.49875	
	brake horsepower	bhp		1/745.6999	
	kilowatt	kW		1×10^{-3}	
	electron volt	ev	Energy	$1/1.6021764874\times10^{-19}$	0
	joule	**J**		**1**	
	calorie (int. steam table 1956)	cal		1/4.1868	
	kilo joule	kJ		1×10–3	
	watt hour	Wh		1/3600	
	kilocalorie	kcal		1/4186.8	
	kilowatt hour	kWh		1/3600000	
	foot-pound force	ftlb		1/1.3558179483314004	
	british thermal unit	BTU		$1/1.05505585262\times10^{3}$	

Unit Set	Unit	Symbol	Category	Factor	Off-set
TEM-PERA-TURE / PRES-SURE	**kelvin**	**K**	Tempera-ture	**1**	**273.15**
	degree Fahrenheit	°F		1.8	32
	degree Celsius	°C		1	0
	degree Réaumur	°Ré		0.8	0
	pascal	Pa	Pressure	1×10^{5}	0
	atmosphere technical	at		1/0.980665	
	bar	**bar**		**1**	
	atmosphere standard	atm		1/1.01325	
	Torr (mm of Hg)	Torr		$1/1.33322387415\times10^{-3}$	
	foot of water	ftW		33.4560927	
	inch of mercury	inHg		$1/3.386389\times10^{-2}$	
	pound/square inch	psi		$1/6.894757\times10^{-2}$	

Unit Set	Unit	Symbol	Category	Factor	Off-set
SPEED / TIME*	**meter per second**	**m/s**	Velocity	**1**	0
	kilometer per hour	km/h		3.6	
	knot	knot		3.6/1.852	
	mile per hour	mph		1/0.44704	
	foot per second	fps		1/0.3048	
	second	s	Time*	86400	0
	minute	min		1440	
	hour	h		24	
	day	**day**		**1**	
	year (365 days)	year		1/365	

* For advanced time calculations the unit set TIME AND FRAMES CALC. can be used.

Unit Set	Unit	Symbol	Category	Factor	Off-set
SI PREFIX	yocto-	y	SI Prefix	1×10^{24}	0
	zepto-	z		1×10^{21}	
	atto-	a		1×10^{18}	
	femto-	f		1×10^{15}	
	pico-	p		1×10^{12}	
	nano-	n		1×10^{9}	
	micro-	μ		1×10^{6}	
	milli-	m		1×10^{3}	
	centi-	c		1×10^{2}	
	deci-	d		1×10^{1}	
	base unit	**base**		**1**	

Unit Set	Unit	Symbol	Category	Factor	Off-set
SI PREFIX (continued)	deca-	da	SI Prefix (contin-ued)	1×10^{-1}	0
	hecto-	h		1×10^{-2}	
	kilo-	k		1×10^{-3}	
	mega-	M		1×10^{-6}	
	giga-	G		1×10^{-9}	
	tera-	T		1×10^{-12}	
	peta-	P		1×10^{-15}	
	exa-	E		1×10^{-18}	
	zetta-	Z		1×10^{-21}	
	yotta-	Y		1×10^{-24}	

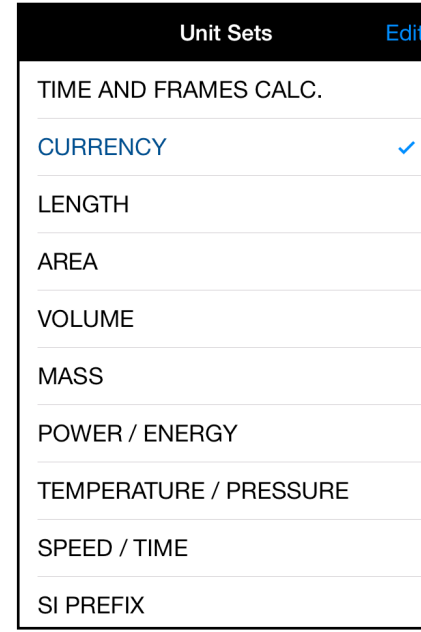
Notes:

- Each unit is assigned to a unit category as shown in the tables. Only units of the same category can be converted into each other. Each category is assigned a color for easy recognition.
- A unit set can hold units of more than one category (except the TIME AND FRAMES CALC.).
- A unit is converted into another unit, using the factors and offsets. For each category there is a unit with the factor 1 (shown in boldface). This unit is called the base unit of the category, and all other units of the same category are related to it. The calculator uses the following equation to convert a value from one unit to another unit:

$$value_2 = \frac{value_1 - offset_1}{factor_1} \times factor_2 + offset_2$$

Time and Frames Calculator

This unit set allows calculations with time and frame rate values and conversions between different time formats. It uses specialized calculation rules and display formats. In contrast to all other unit sets this unit set does not support user defined units. See the chapter “Time Calculations” for more information about using this unit set.



Selecting a Unit Set

When the units mode is shown, then the recently used unit set will be active. To use a different unit set press the UNIT key and select the desired unit set in the displayed selection list.

Different View Modes

In units mode for each unit set a “single line” or “two lines” view mode can be selected independently. By default the “two lines”

view mode is selected for the “Time and Frames Calculator” and for the Currency unit sets. All other unit sets use the “single line” view mode by default.

- To switch from “two lines” to “single line” view mode Enter: [2nd L] [2nd F] [CU] (This clears the unit of the second line.)
- To switch from “single line” view mode to “two lines” view mode press the [2nd L] key followed by a units key. (This specifies the unit for the second line.)

Single Line View Mode

The “single line” view mode of the units mode can be seen as extension to the scientific mode where unit conversions can be performed. The actual value will be simply converted without permanently assigning it to a unit. For this reason, opposite to the “two lines” view mode there are no restrictions in the calculations which can be performed.

An Outline of Some of the Major Key Functions

✳ Unit Keys [€], [mm], [oz], [°C] etc.

With the unit keys a displayed number can be converted from one unit to another. For conversion two unit keys have to be pressed in sequence. The shown number will be converted from the first into the second unit. A conversion can only be performed between units of the same category.

Example:
Conversion from 12.5 inch to millimeter.
Press [UNIT] and select the unit set LENGTH to switch to the units for length conversion.

Enter	Display
12.5	12.5
[in]	12.5 **in**
[mm]	317.5

Result: 12.5 inch are 317.5 mm

How many feet and inch are 1.75 m?

Enter	Display
1.75 [m]	1.75 **m**
[ft]	5.7414698162729658793
	Result 1: 5 feet
[−] 5 [=] [ft]	0.7414698162729658793 **ft**
[in]	8.8976377952755905516
	Result 2: 8.9 inch

Result: 1.75 m are 5 feet and 8.9 inch.

✳ [FSE] and [TAB] (display mode switch)

In “single line” view mode the calculator uses the same display mode and number of decimal places as in scientific mode which can be specified with the [FSE] and [TAB] keys. So changing these also affects the settings of the scientific mode. See chapter 3 “SCIENTIFIC MODE” for further reference.

✳ [2nd L] (switching to “two lines” view mode)

With the key [2nd L] and a following unit key the calculator can be switched from “single line” view mode to “two lines” view mode. For the second display line the pressed unit will be selected. For the first display line a unit compatible to the unit of the second line will be used. If in “single line” view mode a unit is currently specified then this unit will also be used for the first display line in “two lines” view mode if it is compatible with the one selected for the second line.

Example:
Conversion of 3.8, 14.6 and 26.6 square meters to the corresponding square yards by using the “two lines” view mode and thereafter switching back to “single line” view mode.
Press [UNIT] and select the unit set AREA to switch to the units for area conversion.

Enter	Display
[C·CE] 3.8 [m^2]	3.8 **m^2**
[2nd L] [yd^2]	3.8 m^2
	4.5447621759441049746 yd^2
[C·CE] 14.6	14.6 m^2
	17.461454675995771745 yd^2
[C·CE] 26.6	26.6 m^2
	31.813335231608734822 yd^2
[2nd L] [2nd F] [CU]	26.6

Two Lines View Mode

The “two lines” view mode is especially useful for fast and easy conversions between two units. On the display two lines will be shown. User inputs are displayed in the first line. In the second line the entered or calculated value can instantly be viewed in a different unit. The numbers displayed in the two lines always represent the same value but in different units.

An Outline of Some of the Major Key Functions

✳ Unit Keys [€], [mm], etc.

With the unit keys the unit of the number in the first display line can be specified. By pressing the [€] key for example the currency Euro will be assigned as unit to the value of the first line on the display. During input of a number the unit can be assigned at any time without effecting the numerical value.

✳ [2nd L] (specify second line)

With the [2nd L] key you specify the second display line. The consecutively pressed key will be related to the second display line instead of the first display line. So by pressing [2nd L] [US$], the currency unit US Dollar will be assigned to the second line. If the unit of the second line will be changed then the numerical value of the second line will also be changed because the value of the first line will be converted to the new unit of the second line. Only a unit from the same category as the unit in the first line can be selected for the second line.

Example:

How many kilogram (kg), are 123.5 pounds (lb)?

Press [UNIT] and select the unit set MASS to switch to the units for weight conversion.

Enter	Display
[C·CE] [lb] [2nd L] [kg]	0. lb 0. kg
123.5	123.5 lb 56.018657695 kg

Showing the 123.5 lb of the last example in ounce (oz):

Enter	Display
2nd L oz	123.5 lb 1 976. oz

To start a new conversion, press the C·CE key first to clear the display and start a new input.

Enter	Display
C·CE	0. lb 0.00 oz
527.9	527.9 lb 8 446.4 oz
2nd L kg	527.9 lb 239.451412123 kg

✳ ↕U (exchange units)

With this key the units of the first line and the second line can be exchanged. Only the units will be new assigned. The values will not be exchanged.

Example:
Conversions between various mass units.

Enter	Display
C·CE oz 2nd L kg	0. oz
	0.00 kg
12.6	12.6 oz
	0.357203991375 kg
↕U	12.6 kg
	444.45192056471320274 oz
C·CE	0. kg
	0.00 oz
100	100. kg
	3 527.3961949580412916 oz

✳ [CU] (clear unit assignment)

If the [CU] key is pressed, the unit assignment for the first display line will be removed. So the number in the first display line has no unit. Simultaneously the second display line will be hidden ("———" will be shown) because a value without a unit can not be converted to a number with a unit.

By pressing [2nd L] [CU], the calculator will be switched into "single line" view mode.

✳ [FSE] and [TAB] (display mode switch)

In "two lines" view mode the calculator uses a separate display mode and number of decimal places setting for every unit set and they can be individually specified for the first and for the second line.
To specify the display mode for the first line press [FSE], to specify it for the second line use [2nd L] [FSE].

1. Specification of 5 decimal digits for the first line.
   Press [UNIT] and select the unit set LENGTH to switch to the units for length conversion.

Enter	Display
[C·CE] [m] [2nd L] [in]	**0.** m **0.** in
[FSE] [2nd F] [TAB] 5	1:FIX **0.00000** m **0.** in
5 [÷] 7 [=]	1:FIX **0.71429 m** **28.121484814398200225** in

2. Specification of 2 decimal digits for the second line.

Enter	Display
2nd L FSE	1:FIX 2:FIX **0.71429 m** **28.121** in
2nd L 2nd F TAB 2	1:FIX 2:FIX **0.71429 m** **28.12** in

✳ CA (clear all)

The 2nd F CA key will clear the operators and/or numeric data that have been entered and also resets the TAB setting to 3 and the display mode to floating point decimal for both lines in the current unit. The memory contents will not be cleared.

Calculations with Mixed Units

In “two lines” view mode the basic operations plus percentage calculations can be performed as shown in chapter 3 “SCIENTIFIC MODE”. However, units will be taken into account. So it is possible to perform calculations with mixed units.

Press [UNIT] and select the unit set “SPEED / TIME” to switch to the units for speed conversions. We will calculate 120 km/h + 20.5 m/s and show the result in mph.

Enter	Display
[C·CE] [km/h] [2nd L] [mph]	0. km/h 0. mph
120	120. km/h 74.564543068480076354 mph
[+]	120. **km/h** 74.564543068480076354 mph
20.5	20.5 km/h 12.738109440865346377 mph
[m/s]	20.5 m/s 45.857193987115246957 mph
[=]	53.833333333333333333 **m/s** 120.42173705559532331 mph

The result of calculations with units is displayed in the unit of the second operand, if one has been assigned. Otherwise, the unit of the first operand will be used for the result. Not all unit combinations are valid in calculations.
By trying to apply an illegal calculation, the calculator will be set into an error condition and "**E**" will be displayed. The error condition can be cleared by pressing the [C·CE] key.

The following table shows combinations of operations and their resulting units:

Unit of Operand 1	Operation	Unit of Operand 2	Unit of Result
A	+	B	B
A		none	(illegal op.)
none		B	(illegal op.)
none		none	none
A	−	B	B
A		none	(illegal op.)
none		B	(illegal op.)
none		none	none
A	×	B	(illegal op.)
A		none	A
none		B	B
none		none	none
A	÷	B	none
A		none	A
none		B	(illegal op.)
none		none	none

On multiplications and divisions the calculator selects no unit for the second operand by default but a unit can be assigned to the second operand explicitly. Press [UNIT] and select the unit set “TEMPERATURE / PRESSURE” to switch to the units for pressure conversions.

Enter	Display
[C·CE] [inHg] [2nd L] [bar]	0. inHg 0.00 bar
1000	1 000. inHg 33.86389 bar
[÷]	1000. **inHg** 33.86389 bar
3	3. — — —
[=]	333.33333333333333333 **inHg** 11.287963333333333333 bar

Enter	Display
C·CE	0. inHg 0. bar
1000	1 000. inHg 33.86389 bar
÷	1 000. **inHg** 33.86389 bar
20	20. — — —
atm	20. atm 20.265 bar
=	1.6710530471255859857 — — —

After pressing an operator key (+, ÷ etc.) or the keys =, M1+ and 2nd F M2+ the unit assigned to the value in the first line of the display will be shown in bold face. This indicates, that the unit is dedicated to the value. Pressing a unit

key in this situation yields to a conversion of the value to the new unit and not the simple assignment of a new unit to the value.

Parenthesis and Priority Levels of Operations

During the processing of complex expressions the calculator follows a set of predefined priorities which determine the sequence in which the operators have to be applied. In units mode, the same rules for priority of operators and parenthesis are valid as described in “SCIENTIFIC MODE” in section “Priority Levels”.

Usage of the Memories

The usage of the memories in units mode is basically the same as in scientific mode. Units are ignored when values are added to memory. No unit conversion is performed.
In “two lines” view mode normally the value in the first display line will be stored in the memory. However, by using the [2nd L] key the value of the second display line can be stored. Press one of the following key sequences: [2nd L] [x→M1], [2nd L] [M1+], [2nd L] [2nd F] [x→M2] and [2nd L] [2nd F] [M2+] for the independently accessible memory or [2nd L] [STO] followed by a number key to store the value of the second line in one of the 10 designated memory slots 0 to 9.

Combining Units and Scientific Modes

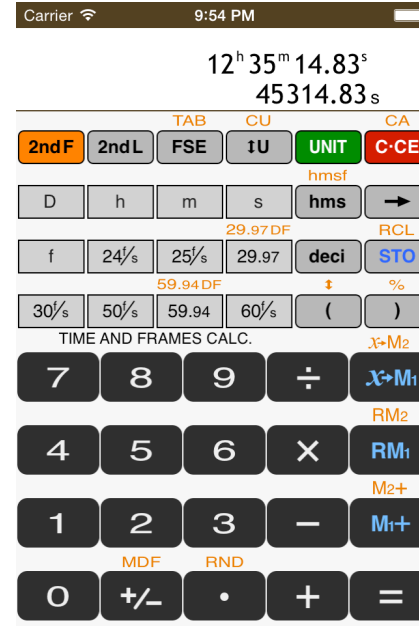
During input of a calculation the calculator can be switched between units and scientific mode at any time without loosing the pending operations and entered digits. Especially the “single line” view mode can be used in combination with the scientific mode.

Example:
Calculate the Area of a circle with a radius of 2 feet, 18 inch in square meters.
Formula: $A = \pi r^2$
Press [UNIT] and select the unit set LENGTH to switch to the units for currency conversion.

Enter	Display
[2nd F] [CA] [2nd L] [2nd F] [CU]	0.
[(] 2 [ft]	2. **ft**
[m]	0.6096
[+] 18 [in]	18 **in**
[m]	0.4572
[)]	1.0668
[x^2] [×]	1.1380622
Switch to SCIENTIFIC mode	
[2nd F] [π]	3.1415926535897932385
[=]	3.5753279725119441341

Result: $A = 3.575\ \text{m}^2$

Time Calculations



The unit set TIME AND FRAMES CALC. is specially designed for doing calculations based on times. Time values can be handled in sexagesimal system (hours, minutes, seconds) and in decimal system. With the [hms] key the sexagesimal time format will be selected and with the [deci] key the decimal format.

1. Input of Sexagesimal Time Values

A sexagesimal time value is entered as individual elements: hours (h), minutes (m) and seconds (s). For this, the corresponding number will be keyed in and in sequence the appropriate unit key ([h], [m], [s]) will be pressed. When pressing the unit key the unit of the entered number will be defined and it will be switched to the next element so that this can be entered. The elements of a sexagesimal time value have to be entered starting from highest to lowest order. This means the value for the hours

must be entered before the minute value and that before the seconds value. Not used elements (that are all zero) can be omitted.

Example:
Input of 5 hours, 9 sec. and reading the seconds in the second line.

Enter	Display
[2nd F] [CA]	$00^h\ 00^m\ 00^s$
	0. s
5	5 h
	18 000. s
[h]	5^h
	18 000. s
9	$5^h\ 9$ m
	18 540. s
[s]	$5^h\ 9^s$
	18 009. s

Result: $5^h\ 9^s$ correspond to 18009 seconds.

Note: The key sequence [2nd F] [CA] resets the calculator to the standard time format: “two lines” view mode with sexagesimal time display (hours, minutes, seconds and fractions of seconds) in the first display line and decimal seconds in the second display line.

During input of a sexagesimal time for the element currently being entered the next lower unit will automatically be suggested and shown following the value:

Enter: 5 [h] 9

Display: $5^h\ 9\ m$ value that currently will be entered with suggested unit.

When a unit key will be pressed, then a unit will be explicitly assigned to the value and the unit symbol will be shown in superscript.
When in the shown situation the key [m] will be pressed, then the suggested unit “minutes” will be accepted ($5^h\ 9^m$) and a seconds value can further be entered. If on the other hand in the shown situation the key [s] will be pressed, then the suggested unit “minutes” will not be accepted and instead of that the entered value will be defined as seconds value. The minutes value will be omitted and so automatically be set to zero): $5^h\ 9^s$ or $05^h\ 00^m\ 09^s$.

Hint:
If the suggested unit is the desired unit and no other elements need to be entered, then pressing the terminating unit key is not necessary:
Entering 5 [h] 9 is identical with 5 [h] 9 [m].

With the help of the key [D] the number of days can be entered:

Enter	Display
[C·CE] 3 [D]	3^{D} 259 200. s
2 [h]	$3^{D}\ 2^{h}$ 266 400. s
[=]	$74^{h}\ 00^{m}\ 00^{s}$ 266 400. s

During entry, for the individual unit elements even fractions can be entered. They will then be converted to a normalized sexagesimal time value.

Example:
Display of 5.5 hours, 12.9 minutes and 83.72 seconds in sexagesimal time format.

Enter	Display
5.5 [h]	5.5^h 19 800. s
12.9 [m]	$5.5^h\ 12.9^m$ 20 574. s
83.72 [s]	$5.5^h\ 12.9^m\ 83.72^s$ 20 657.72 s
[=]	$05^h\ 44^m\ 17.72^s$ 20 657.72 s

Result: 5 hours, 44 minutes and 17.72 seconds.

2. Defining the Display Format of Sexagesimal Time Values

After a calculation or after pressing the [C·CE] key, with the help of the unit keys it can be specified how the result should be displayed. By pressing a unit key ([D], [h], [m], [s]) the base of the sexagesimal value will be selected. This defines what unit will be displayed as the highest element of a sexagesimal value.

Example:

Enter	Display
[C·CE] [hms]	$00^h\ 00^m\ 00^s$ 0. s
95 [h] 3 [m] 8.65	$95^h\ 3^m\ 8.65$ s 342 188.65 s
[=]	$95^h\ 03^m\ 08.65^s$ 342 188.65 s
[m]	$5703^m\ 08.65^s$ 342 188.65 s
[D]	$3^D\ 23^h\ 03^m\ 08.65^s$ 342 188.65 s

Note: The same time value is shown in different formats.

The lowest element of a sexagesimal value can be defined by pressing [2nd F] [TAB] followed by a unit key. For the lowest element decimal fractions will also be shown if needed.

(continue of the last example)

Enter	Display
	$3^{D}\ 23^{h}\ 03^{m}\ 08.65^{s}$ 342 188.65 s
2nd F TAB m	$3^{D}\ 23^{h}\ 03.144166666666666^{m}$ 342 188.65 s
2nd F TAB h	$3^{D}\ 23.05240277777777777^{h}$ 342 188.65 s
hms	$95^{h}\ 03^{m}\ 08.65^{s}$ 342 188.65 s

Note: The same time value is shown in different formats.

With the key hms the display format will be reset to the default for sexagesimal time values (hours, minutes, seconds and fractions of seconds).
The selected display format does not restrict the possibilities during entry. By pressing the corresponding unit key during input, every element can be entered. After input is complete the time value will be converted to the selected format.

3. Decimal Time Formats

Every time unit ([D], [h], [m], [s]) can also be used in decimal form. To activate the decimal time display press the [deci] key.

Example:

Conversion of the following decimal hour values to their seconds equivalent: 1234.34 h as well as 1/7 h

Enter	Display
[C·CE] [deci] [h]	0. **h** 0. s
1234.34	1234.34 h 4443 624 s
[C·CE] 1 [÷] 7 [=]	0.1428571428571428571 **h** 514.28571428571428571 s

Result: 1234.34 h correspond to 4443624 s and 1/7 h to 514.29 s.

4. Calculating With Times

Time values can be used in calculations like all the other units.

Example 1:
In a swimming relay team the individual swimmers have the following times:
A 1:03.26 B :55.02 C :57.97 D :56 (minutes:seconds)
What is the overall time?

We switch to “single line” view mode: [2nd L] [2nd F] [CU]

Enter	Display
[C·CE] [hms]	$00^h\ 00^m\ 00^s$
1 [m] 3.26 [+]	$00^h\ 01^m\ 03.26^s$
55.02 [s] [+]	$00^h\ 01^m\ 58.28^s$
57.97 [s] [+]	$00^h\ 02^m\ 56.25^s$
56 [s] [=]	$00^h\ 03^m\ 52.25^s$

Result: The overall time is 3:52.25.

An alternative way to calculate this: the time values are mostly seconds so we can simplify the entry when we switch the sexagesimal base for the first line to seconds. The second line we also switch to sexagesimal format, with minutes as base, so we can directly read the result:

Enter	Display
[C·CE] [s]	00^{s}
[2nd L] [hms] [2nd L] [m]	00^{s} $00^{m}\ 00^{s}$
1 [m] 3.26 [+]	63.26^{s} $01^{m}\ 03.26^{s}$
55.02 [+]	118.28^{s} $01^{m}\ 58.28^{s}$
57.97 [+]	176.25^{s} $02^{m}\ 56.25^{s}$
56 [=]	232.25^{s} $03^{m}\ 52.25^{s}$

Example 2:
The qualification time for 200 yard free relay is 1:48.19.
Calculate the average time needed by each swimmer to make that time:

Enter	Display
[2nd F] [CA] [m]	$00^{m}\ 00^{s}$
	0. s
1 [m] 48.19	$1^{m}\ 48.19$ s
	108.19 s
[÷] 4	4
	— — —
[=]	$00^{m}\ 27.0475^{s}$
	27.0475 s

Result: The average time for each swimmer is 27.05 seconds.

5. Calculating With Frame Rates

The calculator supports calculations with the most commonly used frame rates:

Button	Description
24 f/s	24 frames per second cinema standard
25 f/s	25 frames per second PAL video standard
29,97	29.97 frames per second NTSC color video standard non drop frames
29.97 DF	29.97 frames per second NTSC color video standard drop frames
30 f/s	30 frames per second NTSC-black and white video standard
50 f/s	50 frames per second PAL video standard
59,94	59.94 frames per second NTSC color video standard non drop frames
59.94 DF	59.94 frames per second NTSC color video standard drop frames
60 f/s	60 frames per second NTSC video standard

Input and calculations with frame rates is the same as with sexagesimal time values but in this case instead of fractions of seconds, the number of frames will be entered and displayed. To activate the display of frame rates press the buttons [2nd F] [hmsf] or press one of the frame rate unit keys.

Example 1:
Calculate the number of seconds that elapsed when the time code value is 00:12:06:23 with 25 frames per seconds.

Enter	Display
[C·CE] [2nd F] [hmsf] [25f/s]	$00^h\ 00^m\ 00^s\ 00^f$ 25f/s 0. s
12 [m] 6 [s] 23	$12^m\ 6^s\ 23$ 25f/s 726.92 s
[2nd L] [hms]	$12^m\ 6^s\ 23$ 25f/s $00^h\ 12^m\ 06.92^s$

Result: The time code 00:12:06:23 with 25 f/s corresponds to 726.92 seconds or 12 minutes and 6.92 seconds.

Example 2:
Conversion between different time code formats. The NTSC 29.97 drop frame time code shows 01:45:23;14. Calculate the corresponding non drop frame time code and the number of real frames.

Enter	Display
[C·CE] [2nd F] [29.97DF] [2nd L] [deci] [2nd L] [29.97]	$00^h\ 00^m\ 00^s\ 00^f$ 29.97DF 0, 29.97f/s
1 [h] 45 [m] 23 [s] 14 [=]	$01^h\ 45^m\ 23^s\ 14^f$ **29.97DF** 189 514, 29.97f/s
[29.97]	$01^h\ 45^m\ 17^s\ 04^f$ **29.97f/s** 189 514, 29.97f/s

Result: 01:45:23;14 DF correspond to 01:45:17:04 NDF and 189514 NTSC frames.

6. Sexagesimal Time Values in Other Operating Modes

Sexagesimal time values are stored internally as decimal seconds. The sexagesimal display is only available in the unit set TIME AND FRAMES CALC. In all other situations the corresponding seconds value will be displayed.

Defining Units

It is possible to add new units to the already predefined units. Further it is possible to change or delete the predefined units.
The calculator uses the following formula to convert from unit 1 to unit 2:

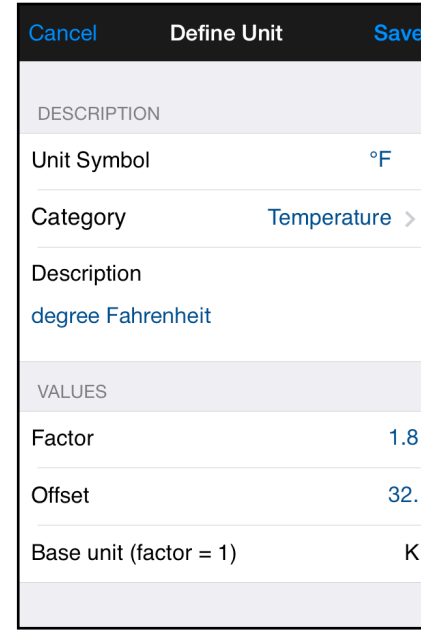
$$value_2 = \frac{value_1 - offset_1}{factor_1} \times factor_2 + offset_2$$

If a unit should be defined *factor* and *offset* relating to the other units of the same category have to be specified. In most cases for each category a base unit with a *factor* of 1 is defined. The *offset* is needed, if the units have different base points which is the case for example with the temperature units °C, °F and K:

	Factor	Offset
°C	1	0
°F	1.8	32
K	1	273.15

1. Unit Definition Sheet

With the unit definition sheet a new unit can be defined, an existing unit can be modified or deleted. Two units can be assigned to each unit key. The first is accessed by directly pressing the unit key, and the second by pressing [2nd F] followed by the unit key.
Press [2nd F] [DEFINE] followed by the unit key which should be defined. (To define the second unit of a unit key press [2nd F] [DEFINE] [2nd F] followed by the unit key.)
To define a unit, the **Unit Symbol** consisting of up to four characters must be entered, which will be used as label for the unit key. Each unit has to be assigned to a unit **Category**. One of 15 categories can be selected. Only units of the same category can be converted into each other. Also, the conversion **Factor** and **Offset** related to the base unit has to be specified.



The base unit is shown in the sheet if one exists. The calculator recognizes the base unit of a category by its conversion factor of 1.
Optional a **Description** text can be assigned to each unit.

To save the changes close the unit definition sheet using the “**Save**” button, to discard the changes and keep the old values, close the sheet using the “**Cancel**” button.

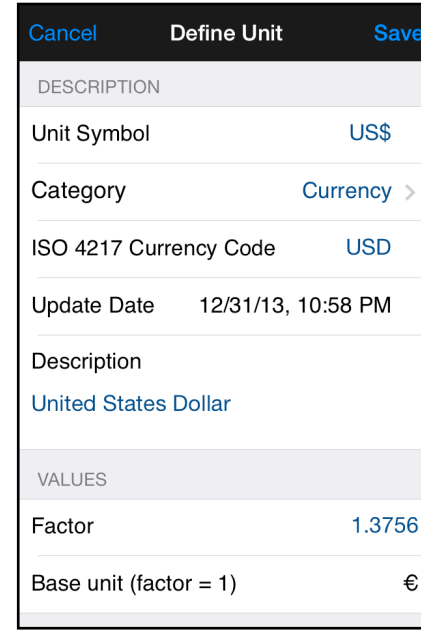
The following table shows all available unit categories:

Unit Categories	
Currency*	Mass
Length	Pressure
Area	Time
Volume	SI Prefix
Power	User 1
Velocity	User 2
Energy	User 3
Temperature	

* The unit category “Currency” has a special feature, it can update the exchange rates (factor) automatically from the internet.

2. Automatic Update of the Exchange Rate

For currency units, that are all units of the category “Currency”, the calculator can update the conversion **Factor** (exchange rate) automatically from the European Central Bank when an internet connection is active and an appropriate three character **ISO 4217 Currency Code** is specified for the unit. This code is used to find the unit on the server. For this feature to work correctly one and only one currency unit in the unit set should be assigned a Factor of 1 (and must also have a valid ISO 4217 Code). This is the base unit to which the exchange rates will be related. By default the Euro is specified as the base unit.
In the field **Update Date** the date and time of the last update of exchange rates is shown (or <none> if it was never updated from the server).



By default the exchange rates will be updated once a day. The update will also be triggered when the “Define Unit” sheet is closed with the “**Save**” button.

Note:
If an **ISO 4217 Currency Code** is specified for a currency unit, but the exchange rate for this unit could not be read from the finance server during the last update, then the unit button will be displayed with a light red color instead of white, to indicate that the exchange rate for this currency may be inaccurate.

3. Delete a Unit

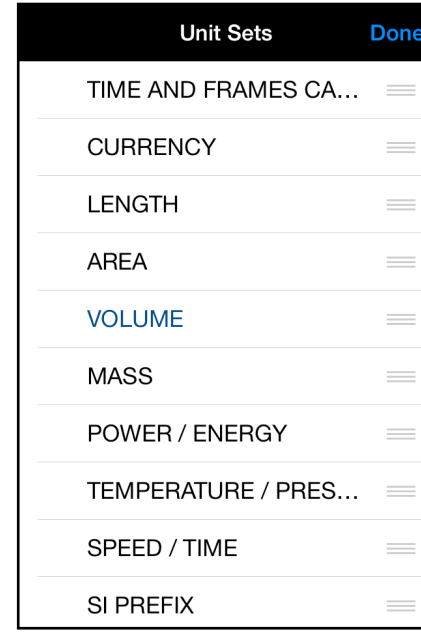
To delete a unit from the unit set, simply clear the **Unit Symbol** in the unit definition form and close the sheet using the “**Save**” button.

Defining Unit Sets

The calculator supports 12 unit sets. Press the UNIT key to show a list of all unit sets. To rename or reorder the unit sets press the “**Edit**” button in the header line of the unit set list. This switches the list to edit mode:

- By dragging an entry on the reordering stripes at the right side, the order of the unit set entries in the list can be changed.

- By tapping a unit set name the “Define Unit Set” sheet opens:



Define Unit Set Sheet

In the “Define Unit Set” sheet the name for the unit set can be changed.

For a unit set with predefined units, the unit set can be reset to factory defaults by using the “**Reset to Factory Defaults**” button. **Attention:** this deletes all user defined or user modified units in this unit set after the sheet is saved.

Following is a list of all unit sets with their predefined names:

Name of the unit set	Description
TIME AND FRAMES CALC.	Time and frame rate calculator
CURRENCY	Currency units
LENGTH	Length units
AREA	Area units
VOLUME	Volume units
MASS	Mass (weight) units
POWER / ENERGY	Power and energy (work) units
TEMPERATURE / PRESSURE	Temperature and pressure units
SPEED / TIME	Speed (velocity) and time units
SI PREFIX	SI prefixes
User 1	Empty unit set 1
User 2	Empty unit set 2
User 3	Empty unit set 3

CHAPTER 5
LOGIC MODE

Computer engineers and programmers are in need of simple conversions between various numeric systems as well as for calculations with Boolean logic. The calculator can operate with integer values up to a bit width of 64 bits in four different numeric systems.

Note:
You should first read the sections “Calculations”, “An Outline of Some of the Major Key Functions” and “Basic Operations” in the chapter 3 “SCIENTIFIC MODE”, to get familiar with the operation of the calculator and its basic functions before you use the logic mode.

Conversion Between Different Numeric Systems

[→HEX] To convert a number to its hexadecimal equivalent; at the same time the calculator will be switched to hexadecimal notation (HEX is shown on the display.)

[→DEC] To convert a number to its decimal equivalent; at the same time the calculator will be switched to decimal notation. (DEC is shown on the display.)

[→OCT] To convert a number to its octal equivalent; at the same time the calculator will be switched to octal notation. (OCT is shown on the display.)

[→BIN] To convert a number to its binary equivalent; at the same time the calculator will be switched to binary notation. (BIN is shown on the display.)

Displaying a number in two numeric systems at the same time

The Logic Mode can show two lines on the display at the same time. This allows entering a number in one numeric system and a the same time showing the same number in another numeric system. The number has to be entered in the numeric system that was selected for the first line, as described above.

- To select the numeric system for the second line press [2nd L] followed by [→HEX], [→DEC], [→OCT] or [→BIN].

- To exchange the numeric systems of the first an second line press [2nd F] [↕L].
- To hide the second line press [2nd L] [C·CE].

Example:
Display decimal 127 in hexadecimal notation:
Press the [→DEC] key to activate the decimal notation for the first line (DEC should be shown above the first line).
Press the keys [2nd L] [→HEX] to select the hexadecimal notation for the second line („HEX“ should be shown above the second line).

Enter	Display
127	32 bit DEC **127** HEX **7F**

The decimal number 127 corresponds to 7F in the hexadecimal notation.

For the following examples in this operation manual only one line of the display will be shown, but all examples can also be performed using two lines mode.

Exercise:

Conversion from decimal 30 to hexadecimal notation:

Press [→DEC] key if calculator is not currently in decimal notation (DEC should be displayed).

Enter	Display
30 [→HEX]	32 bit HEX **1E**

Exercise:

Further conversion of hexadecimal 1E to binary format:

Enter	Display
[→BIN]	32 bit BIN **11110**

1. The Hexadecimal Notation

The hexadecimal notation system is mainly used in computer programming. The base for a hexadecimal number is 16; hexadecimal numbers consist of the digits 0 to 9 and the major letters A to F, which stand for the numbers 10 to 15 in the decimal system.
Keys for the letters A to F will be active when the calculator is in hexadecimal notation. The symbol HEX means, that numerical values on the display are shown in hexadecimal notation and that basic integer arithmetic and Boolean operations can be performed.

2. The Decimal Notation

In logic mode even in decimal notation only integer values with a bit width of a maximum of 64 bits can be handled.
In decimal notation only the keys for the digits 0 to 9 are active. The symbol DEC means, that numerical values on the display are shown in decimal notation and that basic integer arithmetic and boolean operations can be performed.

3. The Octal Notation

The base for an octal number is 8; octal numbers consist of the digits 0 to 7.

In octal notation only the keys for the digits 0 to 7 are active. The symbol OCT means, that numerical values on the display are shown in octal notation and that basic integer arithmetic and boolean operations can be performed.

4. The Binary Notation

The binary notation system is mainly used in computer programming. The base for a binary number is 2; binary numbers consist of the digits 0 and 1.
In binary notation only the keys for the digits 0 and 1 are shown. Further keys to toggle individual bits are shown. A smaller font is used so that 32 positions can be displayed in one row. Additionally, a ruler is shown to support the identification of nibbles, bytes and words.
The calculator will show a 64 bit number in two lines. The first line shows the higher longword and the second line the lower longword.
The symbol BIN means that numerical values on the display are shown in binary notation and that basic integer arithmetic and boolean operations can be performed.

Selecting the Bit Width, Number Display and Sign Mode

The calculator can be switched to bit widths of 8, 16, 32 and 64 bits which are commonly used in the computer industry. With the [↑bit] key the next higher and with the [2nd F] [↓bit] key the next lower bit width is selected. The currently selected bit width is shown on the display: “8 bit”, “16 bit”, “32 bit” or “64 bit”.

With the [2nd F] [fill] key you can switch leading zeros on and off. Press the key once to show numbers with leading zeros filled to the selected bit width (“FILL” will be shown on the display). Press the key again to switch back to normal number display. If “FILL” is activated then leading zeros can also be entered during input.

Example: (Settings: HEX, “16 bit”)

Enter	Display
1AB [=]	16 bit HEX **1AB**
[2nd F] [fill]	FILL 16 bit HEX **01AB**
[↑bit]	FILL 32 bit HEX **0000 01AB**

Enter	Display
000AB8	FILL 32 bit HEX **00 0AB8**
[×]	FILL 32 bit HEX **0000 0AB8**
456 [=]	FILL 32 bit HEX **002E 79D0**
[2nd F] [fill]	32 bit HEX **2E 79D0**

With the [2nd F] [sign] key, the calculator can be switched between signed and unsigned interpretation of a number. On the display the symbol “SIGN” appears if the signed mode is active. Signs are only shown in HEX, DEC and OCT notations. In the BIN notation only the bits are shown, always without interpretation. Negative numbers are coded in 2's complement with the highest bit set, like it is common in the computer industry.
With the [+/−] key the 2's complement of the displayed number will be calculated. In signed mode this yields to a change of the sign. The BIN notation can always

be used to show the coding of a number.

Example:
Settings: “SIGN”, HEX, “16 bit”

Enter	Display
180 [+/–]	SIGN 16 bit HEX **–180**
[2nd F] [sign]	16 bit HEX **FE80**
[→BIN]	16 bit BIN **1111111010000000**

Number Range

The selected bit width in combination with the sign mode has influence on the number range which can be handled. In contrast to the scientific mode, too big numbers do not lead to an error condition in logic mode but to an overflow.

The following tables show the number ranges in logic mode:

Bit Width	Num. Sys.	Sign Mode	Number Range
8 bit	HEX		0 ~ FF
8 bit	HEX	SIGN	–80 ~ 7F
8 bit	DEC		0 ~ 255
8 bit	DEC	SIGN	–128 ~ 127
8 bit	OCT		0 ~ 377
8 bit	OCT	SIGN	–200 ~ 177
8 bit	BIN		0 ~ 11111111
8 bit	BIN	SIGN	0 ~ 11111111
16 bit	HEX		0 ~ FFFF
16 bit	HEX	SIGN	–8000 ~ 7FFF
16 bit	DEC		0 ~ 65535
16 bit	DEC	SIGN	–32768 ~ 32767

Bit Width	Num. Sys.	Sign Mode	Number Range
16 bit	OCT		0 ~ 17 7777
16 bit	OCT	SIGN	–10 0000 ~ 7 7777
16 bit	BIN		0 ~ 1111111111111111
16 bit	BIN	SIGN	0 ~ 1111111111111111
32 bit	HEX		0 ~ FFFF FFFF
32 bit	HEX	SIGN	–8000 000 ~ 7FFF FFFF
32 bit	DEC		0 ~ 4294967295
32 bit	DEC	SIGN	–2147483648 ~ 2147483647
32 bit	OCT		0 ~ 377 7777 7777
32 bit	OCT	SIGN	–200 0000 0000 ~ 177 7777 7777
32 bit	BIN		0 ~ 11111111111111111111111111111111
32 bit	BIN	SIGN	0 ~ 11111111111111111111111111111111

Bit Width	Num. Sys.	Sign Mode	Number Range
64 bit	HEX		0 ~ FFFF FFFF FFFF FFFF
64 bit	HEX	SIGN	–8000 0000 0000 0000 ~ 7FFF FFFF FFFF FFFF
64 bit	DEC		0 ~ 18446744073709551615
64 bit	DEC	SIGN	–9223372036854775808 ~ 9223372036854775807
64 bit	OCT		0 ~ 17 7777 7777 7777 7777 7777
64 bit	OCT	SIGN	–10 0000 0000 0000 0000 0000 ~ 7 7777 7777 7777 7777 7777
64 bit	BIN		0 ~ 1111111111111111111111111111111111 1111111111111111111111111111111111
64 bit	BIN	SIGN	0 ~ 1111111111111111111111111111111111 1111111111111111111111111111111111

Exercise:
Solve of 250 + 15 with unsigned 8 bit arithmetic (overflow calculation):
Press the [→DEC] key to select decimal notation (DEC is shown on the display).
Press the [2nd F] [↓bit] until “8 bit” is shown in display.
With the [2nd F] [sign] key select unsigned mode (symbol “SIGN” cleared in display).

Enter	Display
250 [+] 15 [=]	8 bit DEC **9**

Exercise:
Display the result of the last calculation in binary notation:

Enter	Display
[→BIN]	8 bit BIN **1001**

Basic Arithmetic Calculations

The arithmetic operations addition, subtraction, multiplication and division can be used like in scientific mode, but only integer values can be handled.

1. Addition, Subtraction and Multiplication

Exercise:
Addition of two hexadecimal numbers
A4 + BA =

Enter	Display
[C·CE] [→HEX]	16 bit HEX **0**
A4 [+] BA [=]	16 bit HEX **15E**

Exercise:

32 bit multiplication of the octal number 73 with the binary number 110 and display of the result as a decimal number

73 oct × 110 bin =

Press [↑bit] until “32 bit” is shown in display.

Enter	Display
[C·CE] [→OCT]	32 bit OCT **0**
73 [×] [→BIN]	32 bit BIN **111011**
110 [=]	32 bit BIN **101100010**
[→DEC]	32 bit DEC **354**

Exercise:

(12 + D) × B =

Enter	Display
[C·CE] [→HEX]	32 bit HEX 0
[(] 12 [+]	32 bit HEX 12
D [)]	32 bit HEX 1F
[×] B [=]	32 bit HEX 155

Exercise:

43A – 3CB =
+) A38 – 2FB =

total

Enter	Display
C·CE x→M1	32 bit HEX 0
43A – 3CB M1+	32 bit HEX 6F
A38 – 2FB M1+	32 bit HEX 73D
RM1	32 bit HEX 7AC

2. Division and Modulo

The following hints have to be noted:

- Calculations in logic mode do not take into account fractions.
- The result of a division will always be shown as an integer value. If a fraction results during a calculation, the fractional part is cut and only the integer part will be displayed.

Examples:

Settings: HEX, “32 bit”

Enter: E [÷] 3 [=] Answer: 4

Enter: B [÷] 3 [×] 2 [=] Answer: 6

With the modulo operation the remainder of a division can be computed.

Enter: E [MOD] 3 [=] Answer: 2

3. Complement Calculation

By pressing the [+/–] key it is possible to calculate the complement of a number in a simple way.

Settings: Unsigned mode (symbol “SIGN” not shown), HEX, “32 bit”

Enter: AB [+/–] Answer: FFFF FF55

Boolean Algebra

The operators of the boolean algebra AND, OR, XOR (exclusive or) and NOT can be used. In a logical operation two numbers will be transformed to binary representation and the logical relation will then be evaluated for every bit pair.

The following section will show the results of the logical operators for these bit evaluations:

X	Y	X AND Y
1	1	1
1	0	0
0	1	0
0	0	0

X	Y	X OR Y
1	1	1
1	0	1
0	1	1
0	0	0

X	Y	X XOR Y
1	1	0
1	0	1
0	1	1
0	0	0

X	NOT X
1	0
0	1

After every bit pair has been assigned the corresponding result (a 1 or a 0) according to the above table, the resulting binary number will be converted back to the selected numeric system. This number is the result of the logical operation.

Example:

With the settings “SIGN”, DEC, “8 bit”, please perform the following calculations:

41 AND 27 →
gives
9

41 = 101001
27 = 011011 AND
← 001001

Enter: 41 [AND] 27 [=]

Answer:

SIGN	8 bit	DEC
		9

41 OR 27 →
gives
59

41 = 101001
27 = 011011 OR
← 111011

Enter: 41 [OR] 27 [=]

Answer:

SIGN	8 bit	DEC
		59

41 XOR 27 →
gives
50

41 = 101001
27 = 011011 XOR
← 110010

Enter: 41 [XOR] 27 [=]

Answer:

SIGN	8 bit	DEC
		50

NOT 3 →
gives
–4 (1's complement)

3 = 00000011 NOT
← 11111100

Enter: 3 [NOT]

Answer:

SIGN	8 bit	DEC
		–4

NOT x can generally be computed with the equation NOT $x = -(x + 1)$.

Bit Shift and Bit Rotate Operations

With the keys [2nd F] [«] and [2nd F] [»] it is possible to perform bit shift operations. Thereby the value will be transformed to binary representation and the single bits will be shifted to the left or the right by the given amount. The result will be transformed back to the selected numeric system which yields the result of the operation.

With the keys [2nd F] [ROL] and [2nd F] [ROR] it is possible to perform bit rotate operations. The bits of a binary represented value will be rotated to the left or the right by the given amount. In contrast to the bit shift operations, the bits that are moved out at one end will not disappear but be shifted in at the other end.

1. Bit Shift Right

During the bit shift right operation the single bits of a value will be shifted to the right by the given amount of positions. This is equivalent to a division by the power of 2.

Example:
Calculation of 80 » 3 is equivalent to 80 / 2^3:

	decimal	**binary**
before shifting	80	0101 0000
after shifting	10	0000 1010

Enter	Display
80 [2nd F] [»] 3 [=]	32 bit DEC **10**

In signed mode (“SIGN”) an arithmetical shift right will be performed whereas in unsigned mode a logical shift right is executed. Arithmetical shift means that the sign of a number is retained; logical shift right always results in a cleared sign bit, treating all bits equal.

Example:

Arithmetic shift right of decimal –120 about one position (is equivalent to a division by two) and display of the result as binary and decimal number:

Settings: “FILL”, “SIGN”, “8 bit”

Enter	Display
C·CE →DEC	FILL SIGN 8 bit DEC **0**
120 +/–	FILL SIGN 8 bit DEC **–120**
→BIN	FILL SIGN 8 bit BIN **10001000**
2nd F » 1 =	FILL SIGN 8 bit BIN **11000100**
→DEC	FILL SIGN 8 bit DEC **–60**

Logical shift right of the result from the previous calculation by 2 positions and display of the resulting value in binary notation.

Enter	Display
2nd F sign	FILL 8 bit DEC 196
2nd F » 2 =	FILL 8 bit DEC 49
→BIN	FILL 8 bit BIN 00110001

2. Bit Shift Left

During the bit shift left operation the single bits of a value will be shifted the given amount of positions to the left. This is equivalent to a multiplication with the power of 2.

Example:
Calculation of 3 « 2 is equivalent to 3×2^2:

	decimal	**binary**
before shifting	3	0000 0011
after shifting	12	0000 1100

Enter	Display
3 [2nd F] [«] 2 [=]	32 bit DEC **12**

3. Bit Rotate right

During the bit rotate right operation the single bits of a value will be rotated to the right by the given amount of positions.

Example:
Rotate 13 by 3 positions to the right.
Settings: DEC, “8 bit”

	decimal	**binary**
before rotating	13	0000 1101
after rotating	161	1010 0001

Enter	Display
13 [2nd F] [ROR] 3 [=]	8 bit DEC **161**

4. Bit Rotate left

During the bit rotate left operation the single bits of a value will be rotated to the left by the given amount of positions.

Example:
Rotate 120 by 5 positions to the left.
Settings: DEC, “8 bit”

	decimal	**binary**
before rotating	120	0111 1000
after rotating	15	0000 1111

Enter	Display
120 [2nd F] [ROL] 5 [=]	8 bit DEC **15**

Swapping Bytes and Nibbles

With the [2nd F] [SWAP] key the bytes of a 16 bit, 32 bit or 64 bit number will be swapped. This allows conversions from “little endian” to “big endian” format and vice versa.

Example:

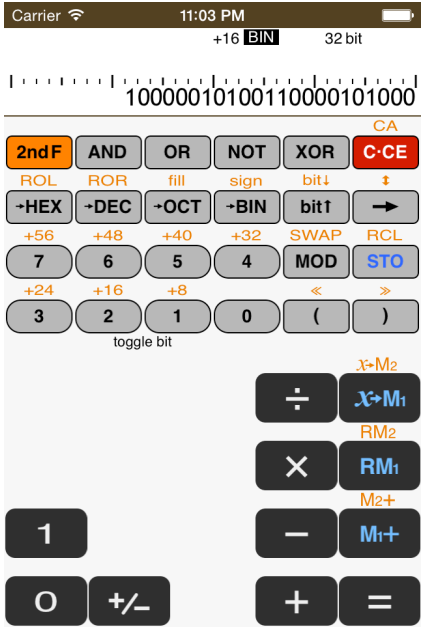
Settings: Unsigned mode, HEX, “64 bit”

Enter	Display
1234567890ABCDEF	64 bit HEX **1234 5678 90AB CDEF**
2nd F SWAP	64 bit HEX **EFCD AB90 7856 3412**
2nd F ↓bit	32 bit HEX **7856 3412**
2nd F SWAP	32 bit HEX **1234 5678**
2nd F ↓bit	16 bit HEX **5678**
2nd F SWAP	16 bit HEX **7856**

In 8 bit notation the nibbles will be swapped (continue from previous example):

Enter	Display
2nd F ↓bit	8 bit HEX 56
2nd F SWAP	8 bit HEX 65

Editing Individual Bits



In the binary notation it is possible to change the value of individual bits by using the bit toggle keys. With the bit toggle keys [0] to [7] individual bits will be toggled. To address bits with a position higher than 7 use one of the bit position selection keys [+8] to [+56]. When pressing a bit position selection key, the corresponding designator “+8” to “+65” appears on the display and the selected bit position is added when using a bit toggle key.
For example if bit position “ +16” is selected, the bit toggle keys [0] to [7] will toggle the bits 16 to 23.
To clear a selected bit position (to address bit 0 to 7), press the same bit position selection key again. The designator will disappear.

You can see it like this: The bit toggle keys can toggle the bits of a byte and with the bit position selection keys the byte position can be preselected.

Example 1:

Set bits 4, 18, 24 and 30 and display value in hexadecimal notation.

Settings: Unsigned mode, BIN, “32 bit”

Enter	Display
C·CE	32 bit BIN **0**
4	32 bit BIN **10000**
2nd F +16 2	+16 32 bit BIN **1000000000000010000**
2nd F +24 0	+24 32 bit BIN **1000001000000000000010000**
6	+24 32 bit BIN **1000001000001000000000000010000**
→HEX	32 bit HEX **4104 0010**

Example 2:

Mask the hexadecimal value C6B1 with the bit mask 1111001111001111.

Settings: Unsigned mode, HEX, “16 bit”

Enter	Display
C6B1	16 bit HEX **C6B1**
[→BIN]	16 bit BIN **1100011010110001**
[AND] 0 [NOT]	16 bit BIN **1111111111111111**
[4] [5]	16 bit BIN **1111111111001111**
[+8] [2] [3]	+8 16 bit BIN **1111001111001111**
[=] [→HEX]	16 bit HEX **C281**

Parenthesis and Priority Levels of Operation

During the processing of complex expressions the calculator follows a set of predefined priorities which determine the sequence in which the operators have to be applied. In logic mode, the same rules for priority of operators and parenthesis are valid as described in “SCIENTIFIC MODE” in section “Priority Levels”. But the additional boolean operators have to be taken into account:

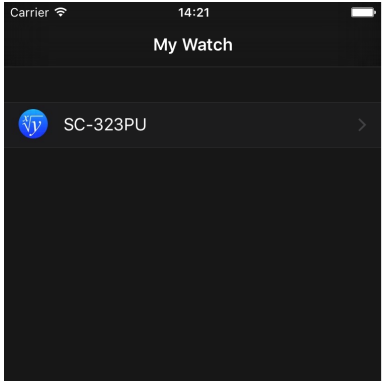
1. Functions like NOT, x^2
2. ×, ÷, MOD
3. +, –
4. «, », ROL, ROR
5. AND
6. XOR
7. OR
8. =, M_1+, M_2+

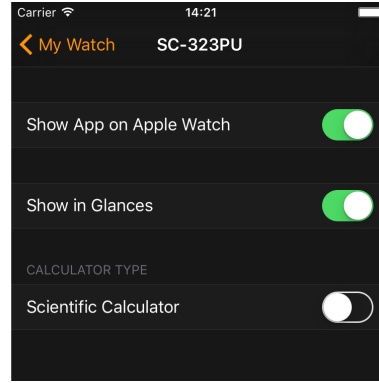
(Calculations which are on the same priority level are executed in sequence.)

CHAPTER 6

Apple Watch CALCULATOR

The Watch Calculator can only be used on the Apple Watch with an iPhone supporting and paired with the Apple Watch.
The calculator on the Apple Watch can operate in **Simple Calculator Mode** or in **Scientific Calculator Mode.** You can select which mode should be used in the Apple Watch App on your iPhone.

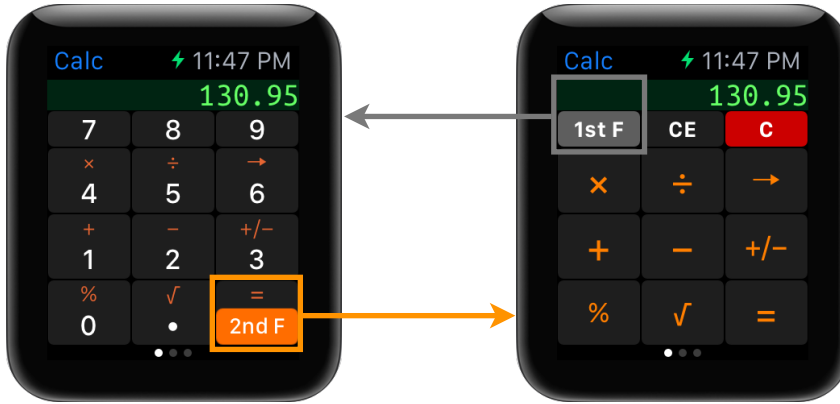




Simple Calculator Mode

The simple calculator mode offers:

- Arithmetic calculations (+, –, ×, ÷) with 10 digits, constant calculation.
- Two independently accessible memories for memory calculations.
- Tip calculator.
- Currency and unit converter.



How to perform basic calculations

In simple mode all calculations will be performed in the order they are entered. There is no operator priority in contrast to the scientific mode.

Example Display	Key operations
 0.	[2nd F] [C]
(–36 + 8) ÷ 5 = –5.6 5.6	[2nd F] [–] 36 [2nd F] [+] 8 [2nd F] [÷] 5 [2nd F] [=] –
17 × (–4) ÷ 2 = –34 34.	17 [2nd F] [×] 4 [2nd F] [+/–] [÷] 2 [2nd F] [=] –
14 + 26 = 40 40.	14 [2nd F] [+] 26 [2nd F] [=]
45 + 26 = 71 71.	45 [2nd F] [=]

42 – 15 = 27	42 [2nd F] [–] 15 [2nd F] [=]	
27.		
28 – 15 = 13	28 [2nd F] [=]	
13.		
64 × 28 = 1792	64 [2nd F] [×] 28 [2nd F] [=]	
1792.		
64 × 50 = 3200	50 [2nd F] [=]	
3200.		

Example Display	Key operations
35 ÷ 14 = 2.5 2.5	35 [2nd F] [÷] 12 [2nd F] [=]
84 ÷ 14 = 6 6.	50 [2nd F] [=]
300×10% = 30 30.	300 [2nd F] [×] 30 [2nd F] [%] [2nd F] [=]
9 ÷ 36 = 25(%) 25.	9 [2nd F] [÷] 36 [2nd F] [%] [2nd F] [=]
30+(30×10%) = 33 33.	30 [2nd F] [+] 10 [2nd F] [%] [2nd F] [=]
$\sqrt{9-5}$ = 2 2.	9 [2nd F] [−] 5 [2nd F] [=] [2nd F] [√]

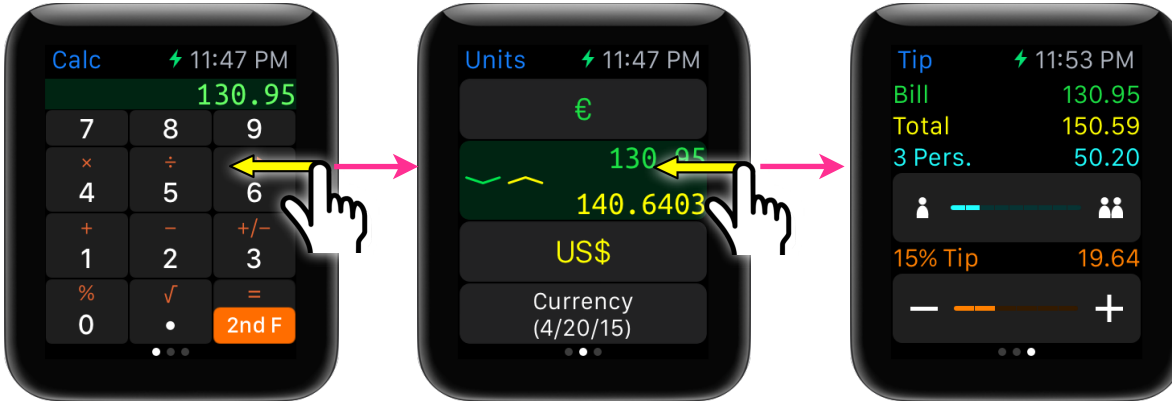
2+16 → 2+7 = 9	2 [2nd F] [+] 16 [2nd F] [CE] 7 [2nd F] [=]	9.
2+128 → 2+15=17	2 [2nd F] [+] 128 [2nd F] [→] [→] [1st F] 5 [2nd F] [=]	17.
6 × 2 → 6 ÷ 2 = 3	6 [2nd F] [×] [2nd F] [÷] 2 [2nd F] [=]	3.
9876543211 ÷ 0.33	9876543211 [2nd F] [÷] 0.33 [2nd F] [×]	2.992891882 10
× 555	555 [2nd F] [=]	1.661054995 13

= $1.661054995 \times 10^{13}$ ($1.661054995 \times 10^{13}$ = 16610549950000)

Tip Calculator and Unit Converter

The entered value or calculation result can be converted to different units including currencies, or can be used as base for tip calculations:

- Swipe left to make unit conversions.
- Swipe left once more to make tip calculations.
- Swipe back to the basic calculator to enter a new value.



Basic Calculator *Unit Converter* *Tip Calculator*

How to perform unit conversions

Enter or calculate the value you want to convert into a different unit or currency and swipe left. Select the desired unit category and the source and destination units within this category. The unit converter displays the entered value in the first line and the converted value in the second line. Use the button above the first line to specify the source unit and the button below the second line to select the destination unit. The unit set is selected by pressing the button at the bottom.
The currency units will be updated daily from the European Central Bank if an internet connection exists and the last update date is shown.

The unit converter offers the following unit categories:
Currency, Length, Area, Volume, Power, Velocity, Energy, Temperature, Mass, Pressure, Time, SI Prefix and optionally three user defined categories.

The Unit Converter on the Apple Watch offers the same units sets and units as the SC-323PU on the iPhone (excluding the “Time and Frames Calculator”). So if you define a new unit or unit set on the iPhone it will also be available on the Apple Watch. See chapter 4 “UNITS MODE” how to define new unit sets and units.

How to perform tip calculations

When you're out at a restaurant, you can use the tip calculator to figure out how much to leave for a tip. Enter or calculate the total amount of the bill in the basic calculator and swipe to the left twice to specify the number of people included on the bill and the percentage of the bill that you want to tip. The tip calculator immediately shows how much each person owes on a bill, making it easy to divide up a bill amongst a table of people.

Bill:	value entered.
Total:	total amount to pay including the tip.
***n* Pers.:**	amount per person to be paid including tip.
***xx*% Tip:**	total amount of the tip.

Memory Calculations

The two memories are accessible via the Memory menu. The menu is shown when performing a force touch in the basic calculator.

To store the actual value into a memory press [x→M1] for first memory or [x→M2] for second memory.
To recall the stored value press [RM1] or [RM2] respectively.
Pressing [M1+] or [M2+] completes the current calculation and adds the result to the value stored in the respective memory. To subtract a number from the memory, press the [2nd F] [+/–] and [M1+] or [M2+] keys.

Scientific Calculator Mode

Scientific calculator mode offers all of the simple mode and additionally:

- Priority of calculations according to a given mathematical formula.
- Trigonometric and inverse trigonometric functions, reciprocals, square roots and cubic roots, xth roots of y ($\sqrt[x]{y}$), squares and powers, logarithmic and exponential functions, factorials.
- DEG/RAD/GRAD selection.
- 30 levels of parentheses or pending operations.
- Different display modes selectable: floating point decimal, fixed point decimal, scientific notation and engineering notation.

Note that multiplication and division have priority over addition and subtraction in scientific calculator mode. In other words, multiplication and division will occur before addition and subtraction.

To switch from Simple Calculator to the Scientific Calculator use the Set Up menu. The menu is shown when performing a force touch in the basic calculator screen.

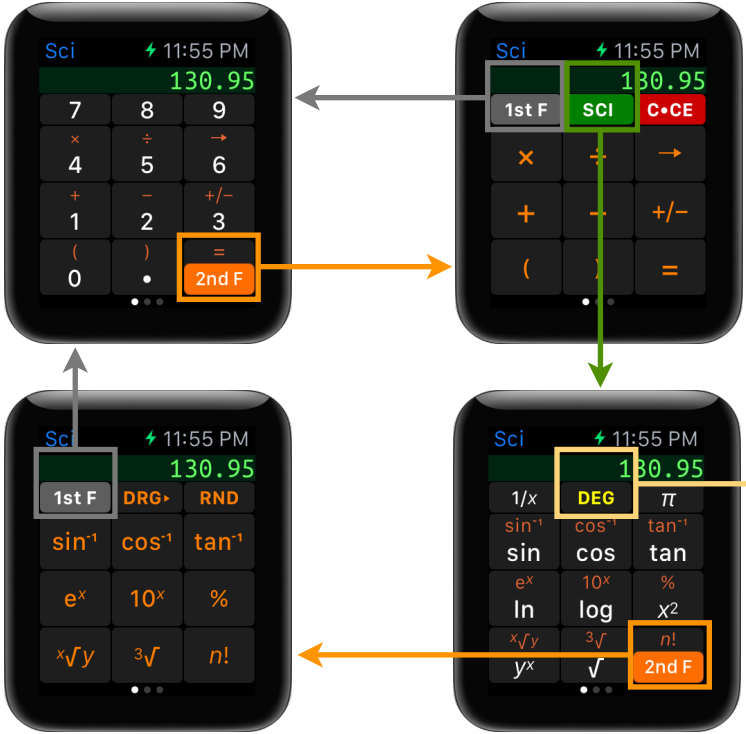
For scientific calculations various decimal formats can be set:

Floating point Answers are given in decimal form with a floating decimal point (default).

Fixed point Answers are given in decimal form. The number of decimal places can be specified.

Scientific Answers are given in “scientific” notation. For example, “3500” is displayed as “`3.500 03`”. The number of decimal places can be specified.

Engineering Answers are given in “engineering” notation with exponents set to be multiples of 3. “100000” will be displayed as “`100.000 03`”, and “1000000” will be shown as “`1.000 06`”. The number of decimal places can be specified.



DEG → RAD → GRAD

This key is used to specify the angular units for numeric data used in trigonometric and inverse trigonometric functions.

To enter a number in exponential form it is necessary to press the decimal point key [•] first. After pressing the [•] key this key will be changed to the [EXP] key used to specify the exponent.

Example Display	Key operations
	[2nd F] [C·CE]
0.	
$4\times10^3 + 5 = -4005$ 4005.	4 [•] [EXP] 3 [2nd F] [+] 5 [2nd F] [=]
$2 \times \log 100 = 4$ 4.	2 [2nd F] [×] 100 [2nd F] [SCI] [log] [2nd F] [=]
$e^{3.4} = 29.96410005$ 29.96410005	3.4 [2nd F] [SCI] [2nd F] [e^x]

For how to use the individual scientific functions and operations refer to chapter 3 “SCIENTIFIC MODE”.

Pasteboard

The calculator can copy values to and from the pasteboard.
To copy the currently displayed value to the pasteboard, double tap on the display and in the appearing menu select “**Copy**”. To copy a value from the pasteboard into the calculator, double tap on the display and select “**Paste**”. The pasted value will be shown on the display.
In units mode if “two lines” view mode is selected the value in the first line and the value in the second line can be independently copied to the pasteboard. Double tap on the desired line. The blue selection shows which line will be used.
Pasting to the calculator is only possible for the first line, which is the line for data input.
In D.A.L. mode you can copy previously entered expressions and results to the pasteboard and then paste them to the actual input line. The text will be inserted at the current cursor position.

Pasteboard Format on Copy

The displayed value will be copied to the pasteboard as text string with the same display format as shown on the display. Unit symbols will not be copied. Exponents will be appended to the mantissa using “E“ between mantissa and exponent.
The following table shows the strings that will be copied to the pasteboard for given display values.

Display	Copied Pasteboard String
123.	123.
125 678.12	125678.12
6.01^{-01}	6.01E-01
123.7^{12}	123.7E12
$3^{D}\ 14^{h}\ 7^{m}\ 8^{s}\ 12^{f}$	3D14h7m8s12f
F2 A3	F2A3

Please note, that the decimal separator used, depends on the selected region format for the system (**Settings** : General > Language & Region > Region).

Pasteboard Formats on Paste

When pasting from the pasteboard the calculator accepts the following characters as exponent indicator: “E” , “e”, and “d”. Spaces will be ignored and the decimal and grouping separator will be interpreted according to the region format settings of the system (**Settings** : General > Language & Region > Region). The calculator stops reading from the pasteboard if a character or symbol appears, that is not valid for a number.

Examples

All of the following pasteboard strings give the value 0.12567812:
125678.12E-06
1 25 678.1 2 e - 6
125678.12 D -006
125,678.12d-6ab123

In logic mode if hexadecimal notation is selected, then in addition to the ten digits 0 to 9 the uppercase and lowercase Letters A to F are also valid.

In the TIME AND FRAMES CALC. unit set sexagesimal time values will also be accepted if for the first display line the sexagesimal format is selected.

Key Functions

C·CE Clear Key
If this key is pressed immediately after numeric data is entered or the content of the memory is recalled, only that data will be cleared. In any other case all operators and/or numeric data that have been entered will be cleared.
Also used to release the calculator from an error condition. The memory contents will remain unchanged even after the clear operation.

2nd F 2nd Function Key
Used to designate the second function of another key. The second function is printed in orange above the key top on the keyboard. **Note:** If this key is pressed by mistake, press the key again to cancel the second function designation.

[0] to [9] Numeral Keys
Used to enter numerical data.
Example: 1234 → [1] [2] [3] [4]

[+/–] Change Sign Key
Changes the sign of the number displayed from a positive to a negative or vice versa.

[2nd F] [MDF] Modify Key
Press for the notation of the calculation result now on the display (number of decimal places) to be used in the next calculation (in contrast to use the internal stored value with all available decimal places).

[•] Decimal Point Key
Used to place the decimal point in the number entered.
Example: 12.3 → [1] [2] [•] [3]
0.7 → [•] [7]

[2nd F] [RND] Random Number Key.
Used to enter a random number.

[÷] Division Key
Press for division.

[×] Multiplication Key
Press for multiplication.

[−] Minus Key
Press for subtraction.

[+] Plus Key
Press for addition.

[=] Equals Key
Completes arithmetic calculations (+, −, ×, ÷, MOD), boolean calculations (AND, OR, XOR), bit shift operations («, »), $\sqrt[x]{y}$, y^x, nCr, nPr and % calculations.

[x→M1] Memory-in Key for First Independently Accessible Memory
Clears the number in the first independently accessible memory and then stores the number being displayed in the memory. To clear the memory press the [C·CE] key followed by the [x→M1] key. (This means to enter zero (0) into the memory).

2nd F **x→M2** Memory-in Key for Second Independently Accessible Memory
Operates like **x→M1** but for the second independently accessible memory.

RM1 Recall From First Independently Accessible Memory
Displays the contents of the first independently accessible memory. The contents of the memory remains unchanged after this key operation.

2nd F **RM2** Recall From Second Independently Accessible Memory
Operates like **RM1** but for the second independently accessible memory.

M1+ Memory Plus Key for First Independently Accessible Memory
Used to add the number being displayed or a calculation result to the contents of the first independently accessible memory. When subtracting a number from the memory, press the **+/–** and **M1+** keys in this order.

2nd F **M2+** Memory Plus Key for Second Independently Accessible Memory
Operates like **M1+** but for the second independently accessible memory.

DRG Degrees/Radians/Grads Selection Key
Used to designate the angle unit (DEG, RAD or GRAD) for calculations of trigonometric and inverse trigonometric functions and for conversion of coordinates. Each time this key is pressed the angle unit is changed.
Example: DEG → GRAD
Press the **DRG** key twice.
"DEG" – Entries and answers are in degrees.
"RAD" – Entries and answers are in radians.
"GRAD" – Entries and answers are in gradients.
180[°] = π [RAD] = 200 [g]

2nd F **DRG►** Angular Unit Conversion Key
Used to convert the displayed value into another angle unit (DEG, RAD, GRAD).

FSE (**2nd F** **FSE** in D.A.L. mode) Display Mode Designation Key
Used to select the display mode from FIX (fixed point decimal), SCI (scientific format), ENG (engineering format) and floating point format.

2nd F **TAB** Tabulation Key
Used to specify the number of decimal positions in a calculation result (for FIX, SCI and ENG display mode).
The number of digits (**0** to **9**) must be pressed following the **TAB** key.
To display all available decimal positions press **2nd F** **TAB** **•**.

CONST Display the list of physical constants.
Used to select a physical constant to use its value in calculations.

2nd F **CA**

Clear All Key
Used to reset the TAB setting to 3 and the display mode to floating point decimal. Also clears the operators and/or numeric data that have been entered. The memory contents will remain unchanged even after the clear all operation.

hyp

Hyperbolic Function Key
Used with the respective trigonometric function keys to calculate hyperbolic functions (sinh, cosh, tanh).

2nd F **archyp**

Inverse Hyperbolic Function Key
Used with the respective trigonometric function keys to calculate inverse hyperbolic functions ($\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$).

sin, **cos**, **tan**

Trigonometric Function Keys
Used to calculate the respective trigonometric functions (sin, cos, tan).

2nd F **sin⁻¹** / **2nd F** **cos⁻¹** / **2nd F** **tan⁻¹**

Inverse Trigonometric Function Keys
Used to calculate the respective inverse trigonometric functions ($\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$).

***n*Cr**

Combinations Key
Used to determine the number of possible combinations when selecting a specific number of items (r) from any number of different items (n).

2nd F ***n*Pr**

Permutations Key
Used to determine the number of possible permutations when arranging a specific number of items (r) selected from any number of different items (n).

→

Backspace Key
Used to delete the last entered digit.

2nd F ***n*!**

Factorial Key
Used to calculate the factorial:
$n! = n\ (n-1)\ (n-2)\ \ldots\ 2 \times 1$.

→DEG D.MS to Decimal Degrees Conversion Key
Used to convert an angle from the sexagesimal notation system (degrees, minutes, seconds) into a decimal equivalent (in degrees).

2nd F **→D.MS** Decimal Degrees to D.MS Conversion Key
Used to convert an angle from the decimal notation system (in degrees) into sexagesimal equivalent (in degrees, minutes, seconds).

ln Natural Logarithm Key
Used to obtain the logarithm to the base e of a number.
(e = 2.7182818284590452354).

2nd F e^x Exponential Function Key
Used to obtain the exponential (antilogarithm to the base e) of a number.

log Common Logarithm Key
Used to obtain the logarithm to the base 10 of a number.

2nd F **10^x** Common Antilogarithm Key
Used to obtain the antilogarithm to the base 10 of a number.

a, *b* Two Parameters Designation Keys
Used to specify the two parameters for coordinate conversions $\rightarrow r\theta$ and $\rightarrow xy$. Press *a* to specify the number being displayed as first parameter; press *b* to specify the number being displayed as second parameter.
After coordinate conversion to display the two results: press *a* to display the first result (default); press *b* to display the second result.

$\Re$, $\Im$ Real and Imaginary Designation Keys
This keys only exist when the calculator is switched to complex calculation mode (CPLX) using rectangular coordinates.
Used to specifiy the real and imaginary part of a complex number.Press $\Re$ to specify the entered value as real part and $\Im$ to specify the entered value as imaginary part.

[r], [θ] Radius and Angle Designation Keys

This keys only exist when the calculator is switched to complex calculation mode (CPLX) using polar coordinates.

Used to specify the radius r and angle θ of a complex value represented as polar coordinates. Press [r] to specify the entered value as radius and [θ] to specify the entered value as angle.

[2nd F] [→rθ] Rectangular to Polar Coordinates Conversion Key

Used to convert rectangular coordinates into polar coordinates.

$(x, y \rightarrow r, \theta)$; $x = 6$ and $y = 4$

Enter: 6 [a] 4 [b] [2nd F] [→rθ]

(Press [b] to display the result of θ.)

[2nd F] [→xy] Polar to Rectangular Coordinates Conversion Key

Used to convert polar coordinates into rectangular coordinates.

$(r, \theta \rightarrow x, y)$; $r = 14$, $\theta = 30°$

Enter: 14 [a] 30 [b] [2nd F] [→xy]

(Press [b] to display the result of y.)

STO Store Key

For how to use this key in D.A.L. mode see section "Using Memories" in chapter 2: "DIRECT ALGEBRAIC LOGIC (D.A.L.)". In the other modes this key is used to store the number displayed in any of the ten memories 0 to 9 by pressing this key followed by one of the number keys **0** to **9**. When these keys (for example **STO** **1**) are pressed after a number is entered (or a calculation result), the number is stored in memory, replacing the contents previously stored in that memory.

2nd F **RCL** Recall Key

For how to use this key in D.A.L. mode see section "Using Memories" in chapter 2: "DIRECT ALGEBRAIC LOGIC (D.A.L.)". In the other modes this key is used to recall the contents of the designated memory. To recall any of the 10 memories 0 to 9, press this key and then one of the designated keys **0** to **9** (Example **2nd F** **RCL** **1**). The contents of the memory remains unchanged after this key operation.

EXP Exponent Key
Used to enter the exponent part of a number.
Example: 1.234×10^{15}
Key in: 1.234 **EXP** 15
Note: There are 2 digits for the exponent part.

2nd F π Pi Key
Used to enter the constant π.
(π = 3.1415926535897932385)

yx Power Key
Raises a number to a power.

2nd F $x\sqrt{y}$ Power Root Key
Calculates the xth root of y.

$\sqrt{\ }$ Square Root Key
Calculates the square root.

2nd F $\sqrt[3]{\ }$ Cubic Root Key
Calculates the cube root.

[x^2] Square Key
Calculates the square.

[2nd F] [$1/x$] Reciprocal Key
Calculates the reciprocal of the number displayed.

[(] Open Parenthesis Key
Used to open a parentheses. Calculations in parentheses have priority over other calculations.

[2nd F] [↕] Exchange
Used to exchange the number being displayed with the number stored in the working register.

[)] Close Parentheses Key
Used to close a parentheses. Calculations in parentheses have priority over other calculations.

[2nd F] [%] Percent Key
Used for percent and percent change calculations.
Example: 45% of 2780
Enter: 2780 [×] 45 [2nd F] [%] [=]

Example: 200 + 20%
Enter: 200 [+] 20 [2nd F] [%] [=]

Units mode:

[2nd L] Second Display Line Designation Key
With this key you specify the second display line (The indicator "2ndL" will be shown on the display if this function is active). The consecutively pressed key will be related to the second display line instead of the first display line. **Note:** If this key is pressed by mistake, press the key again to cancel the second line designation.
Used to specify a unit for the second display line by pressing a unit key after this key.
Used to remove the second display line by pressing [2nd F] [CU] after this key.
Used to store the value displayed in the second line into a memory when this key is pressed before the memory storage key.

Used to specify the display mode and TAB setting when pressed prior to the [FSE] or [2nd F] [TAB] keys.
Used to switch second line to sexagesimal or decimal time format when this key is pressed before [hms], [2nd F] [hmsf] or [deci].

[↕U] Exchange Units Key
Used to exchange the unit displayed in the first line with the unit displayed in the second line.

[2nd F] [CU] Clear Unit Key
Used to remove the unit for the value on the display. Press [2nd L] [2nd F] [CU] to clear the unit of the second line (and switch to “single line” view mode).

[UNIT] Unit Set Selection Key
When pressed, a list with all unit sets is shown. Tab on a unit set name to use this unit set for calculations. Tab the “Edit” button in the unit sets list to rearrange the list entries or to rename the unit set names.

2nd F **DEFINE** Unit Definition Key

Press **2nd F** **DEFINE** followed by a unit key to show the unit definition sheet for this unit. To define the second unit of a unit key, press **2nd F** **DEFINE** **2nd F** followed by the unit key.

This key will also clear all operators and/or numeric data that have been entered.

€, mm, °C, oz, etc. Unit Keys

In "single line" view mode:

Press two unit keys in sequence to convert the value displayed from the first to the second unit.

Example: mm → in

Press: mm in

In "two lines" view mode:

Used to specify the unit of the first display line.

Use **2nd L** followed by a unit key to specify the unit for the second display line. Example: **2nd L** mm

hms Sexagesimal Time Format Key

(only available in TIME AND FRAMES CALC. unit mode)

Used to switch to the sexagesimal time format (hour, minutes, seconds) for the first line. Press [2nd L] [hms] to set sexagesimal time format for the second line.

[2nd F] [hmsf] Frame Rate Format Key
(only available in TIME AND FRAMES CALC. unit mode)
Used to switch to the frame rate format (hour, minutes, seconds, frames) for the first line. Press [2nd L] [2nd F] [hmsf] to set frame rate display format for the second line.

[deci] Decimal Time Format Key
(only available in TIME AND FRAMES CALC. unit mode)
Used to switch to the decimal time format for the first line. Press [2nd L] [deci] to set decimal time format for the second line.

Logic mode:

[A] to [F] Hexadecimal Number Keys
Used to enter the hexadecimal numbers A, B, C, D, E and F.
Example: 3AC → [3] [A] [C]

2nd L Second Display Line Designation Key
Used to specify the numeric notation of the second line on the display. (The indicator “2ndL” will be shown on the display if this function is active). **Note:** If this key is pressed by mistake, press the key again to cancel the second line designation.
Press the **2nd L** key followed by one of the keys **→HEX**, **→DEC**, **→OCT** or **→BIN** to set the second display line to the corresponding numeric system.
Used to hide the second line by pressing **2nd L** **C·CE**.

2nd F **↕L** Used to exchange the numeric notation of the first and second line on the display.

AND AND Key
Press for logical AND operation.

OR OR Key
Press for logical OR operation.

NOT NOT Key
Performs the logical NOT operation to the value displayed.

XOR Exclusive OR Key
Press for logical XOR operation.

→HEX Hexadecimal Number Mode Key
Used to set the hexadecimal number mode. Also converts the number displayed into a hexadecimal number.

→DEC Decimal Number Mode Key
Used to set the decimal number mode. Also converts the number displayed into a decimal number.

→OCT Octal Number Mode Key
Used to set the octal number mode. Also converts the number displayed into an octal number.

→BIN Binary Number Mode Key
Used to set the binary number mode. Also converts the number displayed into a binary number.

2nd F **ROL** Bit Rotate Left Key
Used to rotate the bits of a binary interpreted value by x positions to the left.

2nd F **ROR** Bit Rotate Right Key
Used to rotate the bits of a binary interpreted value by x positions to the right.

2nd F **fill** Fill With Leading Zeros Key
Used to switch between show/hide leading zeros in calculation results for HEX, OCT and BIN numbers. If leading zeros is active the designator “FILL” is shown on the display.

2nd F **sign** Signed/Unsigned Mode Switch Key
Used to switch between signed/unsigned mode. If signed mode is active the designator “SIGN” is shown on the display.

↑bit Increase Bit Width Key
Used to switch to the next higher bit width:
8 bit → 16 bit → 32 bit → 64 bit.

2nd F **↓bit** Decrease Bit Width Key
Used to switch to the next lower bit width:
64 bit → 32 bit → 16 bit → 8 bit.

MOD Modulo Key
With the modulo key the remainder of a division can be computed.

2nd F **SWAP** Swap Key
Used to swap bytes and nibbles. This allows conversions from “little endian” to “big endian” format and vice versa.

2nd F **«** Bit Shift Left Key
Used to shift the bits of a binary interpreted value by x positions to the left. This is equivalent to a multiplication by the power of 2.

2nd F **»** Bit Shift Right Key
Used to shift the bits of a binary interpreted value by x positions to the right. This is equivalent to a division by the power of 2.

In signed mode (“SIGN”) an arithmetical shift right will be performed whereas in unsigned mode a logical shift right is executed. Arithmetical shift means that the sign of a number is retained; logical shift right always results in a cleared sign bit, treating all bits equal.

[0] to [7] — Bit Toggle Keys (only visible in binary notation)
Used to toggle the bit at the corresponding position. If the bit was 0 it will be set to 1 and if it was 1 it will be set to 0.

[2nd F] [+8] to [2nd F] [+56] — Bit Position Selection Keys (only visible in binary notation)
Used in combination with the bit toggle keys to select bit positions higher than 7. If a bit position selection is active, the corresponding designator “+8” to “+56” is shown on the display. To deactivate a bit position selection press it a second time.
Example: [2nd F] [+32] [7] to toggle the bit at bit position 39.

D.A.L. mode:

[CL] Clear Input Key
Clears all characters in the input line or starts a new empty input line.

[2nd F] [CA] Clear Screen Key
Clears the complete screen. Press twice to clear the history of expressions (which can be recalled using [2nd F] [ENTRY]) too.

◀ ▲ ▼ ▶ Cursor Keys
To move the cursor one position left, up, right or down. You can jump the cursor to the start or end of the input line using the keys [2nd F] ◀ and [2nd F] ▶.

[ALPHA] Character Selection Key
This key will is used to access the characters written in blue on the keypad. **Note:** If this key is pressed by mistake, press the key again to cancel the APLHA function designation.

[←] Backspace Key
Deletes the character left to the cursor.

2nd F **SETUP** Display the SET UP Menu
In the SET UP menu you can change the angular unit, the number format for results, the display format for fractions and reset settings and memory contents.

2nd F **;** Enters a semicolon " ; " at the cursor.
A semicolon is required in some of the MATH functions to separate different arguments. For more information, refer to the section "Calculations Using MATH Menu Items" in chapter 2: "DIRECT ALGEBRAIC LOGIC (D.A.L.)".

MATH Display the MATH Menu
The MATH menu contains functions used for more elaborate math concepts, such as trigonometry, logarithms and probability. The MATH menu items may be incorporated into your expressions.

2nd F **CONST** Display the list of physical constants.
Die list shows all the physical constants that can be incorporated into your expressions.

(–) Negative Number Key
To enter negative numbers and functions.

Exp Exponent Entry Key
To enter the “E” sign followed by the exponent value.
Example: 1.234×10^{15}
Key in: 1.234 **Exp** 15

2nd F **ENTRY** Entry Recall Key
Recalls the previous entry (press **2nd F** **ENTRY** more then once to recall older entries).

ENTER Enter Key
To finish the entry of an expression and calculate the result.

For a description of the individual function keys in D.A.L.-Mode see section “Mathematical Operations” in chapter 2: “DIRECT ALGEBRAIC LOGIC (D.A.L.)”.

Physical Constants

The Calculator offers the following 47 physical constants.

(Source: *2018 CODATA recommended values, The NIST Reference on Constants, Units, and Uncertainty. US National Institute of Standards and Technology. June 2019.*)

Name and Symbol	Value	Unit
(1) Speed of light in vacuum c	2.99792458×10^{8}	$m\cdot s^{-1}$
(2) Gravitational constant G	6.67430×10^{-11}	$N\cdot m^{2}\cdot kg^{-2}$
(3) Gravitational acceleration g	9.806665	$m\cdot s^{-2}$
(4) Electron rest mass m_e	$9.1093837015\times10^{-31}$	kg
(5) Proton rest mass m_p	$1.67262192369\times10^{-27}$	kg
(6) Neutron rest mass m_n	$1.67492749804\times10^{-27}$	kg
(7) Muon rest mass m_μ	$1.883531627\times10^{-28}$	kg
(8) Unified atomic mass unit u	$1.66053906660\times10^{-27}$	kg
(9) Elementary charge e	$1.602176634\times10^{-19}$	C

Name and Symbol	Value	Unit
(10) Planck constant h	6.62607015×10^{-34}	J·s
(11) Boltzmann constant k	1.380649×10^{-23}	$J\cdot K^{-1}$
(12) Magnetic permeability $\mu_0 = 4\pi\times10^{-7}$	$1.25663706212\times10^{-6}$	$H\cdot m^{-1}$
(13) Dielectric permittivity ε_0	$8.8541878128\times10^{-12}$	$F\cdot m^{-1}$
(14) Electron charge to mass ratio e/m_e	$-1.75882001076\times10^{11}$	$C\cdot kg^{-1}$
(15) Classical electron radius $r_e = e^2/4\pi\varepsilon_0 m_e c^2$	$2.8179403262\times10^{-15}$	m
(16) Fine-structure constant $\alpha = e^2/4\pi\varepsilon_0\hbar c^2$	$7.2973525693\times10^{-3}$	
(17) Quantum of circulation $h/2m_e$	$3.6369475516\times10^{-4}$	$m^2\cdot s^{-1}$
(18) Bohr radius $a_0 = 4\pi\varepsilon_0\hbar^2/m_e e^2$	$5.29177210903\times10^{-11}$	m
(19) Rydberg constant $R\infty = e^2/16\pi^2\varepsilon_0 a_0\hbar c$	$1.0973731568160\times10^{7}$	m^{-1}
(20) Magnetic flux quantum $\Phi_0 = h/2e$	$2.067833848\times10^{-15}$	Wb
(21) Bohr magneton $\mu_B = e\hbar/2m_e$	$9.2740100783\times10^{-24}$	$J\cdot T^{-1}$
(22) Electron magnetic moment μ_e	$-9.2847647043\times10^{-24}$	$J\cdot T^{-1}$

Name and Symbol	Value	Unit
(23) Free electron g-factor $g_e = 2\mu_e/\mu_B$	-2.00231930436256	
(24) Nuclear magneton $\mu N = e\hbar/2m_p$	$5.0507837461\times10^{-27}$	$J\cdot T^{-1}$
(25) Proton magnetic moment μ_p	$1.41060679736\times10^{-26}$	$J\cdot T^{-1}$
(26) Proton g-factor $g_P = 2\mu_P/\mu_N$	5.5856946893	
(27) Gyromagnetic ratio of proton γ_p	2.6752218744×10^{8}	$s^{-1}\cdot T^{-1}$
(28) Neutron magnetic moment μ_N	-9.6623651×10^{-27}	$J\cdot T^{-1}$
(29) Muon magnetic moment μ_μ	$-4.49044830\times10^{-26}$	$J\cdot T^{-1}$
(30) Compton wavelenght of the electron	$2.42631023867\times10^{-12}$	m
(31) Compton wavelenght of the proton $\lambda_{Cp} = h/$	$1.32140985539\times10^{-15}$	m
(32) Stefan-Boltzmann constant	5.670374419×10^{-8}	$W\cdot m^{-2}\cdot K^{-4}$
(33) Avogadro's constant N_A	6.02214076×10^{23}	mol^{-1}
(34) Molar volume of ideal gas at STP V_m	2.241396954×10^{-2}	$m^3\cdot mol^{-1}$
(35) Gas constant $R = N_A k$	8.314462618	$J\cdot mol^{-1}\cdot K^{-1}$

Name and Symbol	Value	Unit
(36) Faraday constant $F = N_A e$	9.648533212×10^{4}	$C\cdot mol^{-1}$
(37) Josephson frequency-voltage ratio $K_J = 2\varepsilon/$	4.835978484×10^{14}	$Hz\cdot V^{-1}$
(38) Quantum Hall resistance $R_H = h/e^2$	25812.80745	Ω
(39) Electron volt eV	$1.602176634\times10^{-19}$	J
(40) Astronomical unit AU	1.495978707×10^{11}	m
(41) Parsec pc	$3.08567758149137\times10^{16}$	m
(42) Sea mile nmi	1852	m
(43) Angstrom Å	1×10^{-10}	m
(44) Knot kn	1852/3600	$m\cdot s^{-1}$
(45) Torr Torr	101325/760	Pa
(46) Standard atmospheric pressure atm	101325	Pa
(47) Calorie cal	4.1868	J

Error Codes and Error Messages

The here described error messages are only valid for the D.A.L. mode of the calculator. For the error handling of the other operating modes see the next section.

Error Code	Error Message	Description
01	Syntax	Syntax error found in equation.
02	Calculate	Calculation-related error found.
04	Nesting deep	Cannot nest more than 30 numerical values, or functions during execution.
05	Exponent value missing	Exponent value after “E” is missing.
06	Invalid value for calculation	The given value is not valid for this calculation.
07	Datatype	Illegal data type for the calculation. The operation is not supported for complex numbers.

Error Code	Error Message	Description
08	Argument	Inconsistency found in argument of the structured function.
09	Complex	A complex number was entered, but the calculator is not in complex calculation mode (CPLX).
10	Integer value expected	Operation is only valid for integer values.
12	Domain	Argument definition outside of domain.
14	Calculation overflow	Calculation beyond range.
15	Division by zero	Division by 0 occurred.
19	Unknown function	The entered function is unknown.
23	Not pair ( )	Parentheses are not used in a pair.

Error Conditions

The error handling shown here are valid for the scientific, units and logic mode. While in an error condition the display shows the symbol “**E**”:

Error symbol

E **0.**

An error can be cleared by pressing the [C·CE] key.

An error will be raised from a calculation or command which exceeds the capacity of the calculator:

1. If the absolute value of a calculation result is greater than 1×10^{99} (not in logic mode)
2. If a number is divided by 0 (zero) (e.g. 5 [÷] 0 [=])
3. If in units mode an illegal calculation was entered.
4. If the absolute value of a result of memory calculation is greater than 1×10^{99} (not in logic mode)
5. If the pending operations inclusive open parentheses exceeds 30 levels.

6. For scientific functions an error occurs if the calculations exceed the following ranges:

Calculation Range

1. Arithmetic calculation

For calculations with x, the value of x has to be in the given ranges:
$-1\times10^{100} < x \leq -1\times10^{-99}$ for a negative x
$10^{-99} \leq x < 10^{100}$ for a positive x
$x = 0$
The displayed value for x will be limited by the number of displayable positions.

Note:
When the absolute value of a numeric entry or the result of a calculation is less than 1×10^{-99}, this calculator regards the value as 0 (zero) for calculation or display.

2. Function calculation

Calculation accuracy
In principle, calculation errors are ±1 of the last digit. (In case of exponential dis-

play, the calculation errors are ±1 of the last digit of the mantissa display.)
However, a calculation error increases in continuous calculations due to accumulation of each calculation error. (This is the same for y^x ; a^b, $\sqrt[x]{y}$, $\sqrt[a]{\ }$, n!, e^x, ln, etc. where continuous calculations are performed internally.)
Additionally, a calculation error will accumulate and become larger in the vicinity of inflection points and singular points of function (for example, calculating sinh x or tanh x at $x = 0$).

Function	Calculation range
sin x cos x tan x sec x	DEG: $\lvert x \rvert < 1\times10^{20}$ RAD: $\lvert x \rvert < (\pi/180)\times10^{20}$ GRAD: $\lvert x \rvert < (10/9)\times10^{20}$ Further only for tan x and sec x: (n = integer) DEG: $\lvert x \rvert \neq 90\ (2n-1)$ RAD: $\lvert x \rvert \neq (\pi/2)(2n-1)$ GRAD: $\lvert x \rvert \neq 100\ (2n-1)$

Function	Calculation range
csc x	DEG: $\lvert x \rvert < 9\times10^{19}$; $x \neq 0$ RAD: $\lvert x \rvert < (\pi/180)\times10^{20}$; $x \neq 0$ GRAD: $\lvert x \rvert < (10/9)\times10^{20}$; $x \neq 0$ Further (n = integer): DEG: $\lvert x \rvert \neq 180\ (2n-1)$ RAD: $\lvert x \rvert \neq \pi\ (2n-1)$ GRAD: $\lvert x \rvert \neq 200\ (2n-1)$
$\sin^{-1} x$ $\cos^{-1} x$	$-1 \leq x \leq 1$
$\tan^{-1} x$	$\lvert x \rvert < 1\times10^{100}$
$\sec^{-1} x$ $\csc^{-1} x$	$1 \leq \lvert x \rvert < 1\times10^{100}$

Function	Calculation range
sinh x cosh x tanh x	$-227.95592420641052271 \leq x \leq 230.25850929940456840$
$\sinh^{-1} x$	$\lvert x \rvert < 1\times10^{50}$
$\cosh^{-1} x$	$1 \leq x < 1\times10^{50}$
$\tanh^{-1} x$	$\lvert x \rvert < 1$
ln x log x $\log_2 x$	$1\times10^{-99} \leq x < 1\times10^{100}$
e^x	$-1\times10^{100} \leq x < 230.25850929940456840$
10^x	$-1\times10^{100} \leq x < 100$
2^x	$-1\times10^{100} \leq x < 332,19280948873623479$

Function	Calculation range
$\sqrt[3]{x}$	$\lvert x \rvert < 1\times10^{100}$
$1/x$; x^{-1}	$\lvert x \rvert < 1\times10^{100}$; $x \neq 0$
x^2	$\lvert x \rvert < 1\times10^{50}$
$\sqrt{x}$	$0 \leq x < 1\times10^{100}$
$n!$	$0 \leq n < 69$ (n = integer)
D.MS → DEG DEG → D.MS	$\lvert x \rvert < 1\times10^{100}$
y^x ; a^b ($y^x = 10^{x \log y}$)	if $y > 0$, $-1\times10^{100} < x \log y < 100$ if $y = 0$, $x > 0$ if $y < 0$, x = integer or if $1/x$ = uneven ($x \neq 0$) and $-1\times10^{100} < x \log \lvert y \rvert < 100$

Function	Calculation range
$\sqrt[x]{y}$; $\sqrt[a]{\ }$ ($\sqrt[x]{y} = 10^{1/x \log y}$)	if $y > 0$, $-1\times10^{100} < {}^{1}/_{x} \log y < 100$; $x \neq 0$ if $y = 0$, $x > 0$ if $y < 0$, x or ${}^{1}/_{x}$ has to be integer and not zero and $-1\times10^{100} < {}^{1}/_{x} \log \lvert y \rvert < 100$
$x, y \rightarrow r, \theta$	$(x^2 + y^2) < 1\times10^{100}$ $\quad r = \sqrt{x^2 + y^2}$ $y/x < 1\times10^{100}$ $\quad \theta = \tan^{-1}(y/x)$
$r, \theta \rightarrow x, y$	$r < 1\times10^{100}$ $\quad x = r \cos \theta$ $\lvert r \sin \theta \rvert < 1\times10^{100}$ $\quad y = r \sin \theta$ $\lvert r \cos \theta \rvert < 1\times10^{100}$
nPr	$0 \leq r \leq n < 10^{100}$ $\quad n, r$ integer
nCr	$0 \leq r \leq n < 10^{100}$ $\quad n, r$ integer if $n - r < r$, $n - r \leq 69$ if $n - r \geq r$, $r \leq 69$

Function	Calculation range
int÷ ; remain	$0 \leq x < 10^{20}$
→a$^b/_c$ →$^b/_c$	$\lvert x \rvert < 10^{20}$

3. Complex number calculation

In a complex number calculation, a calculation error may occur and increase due to inner continuous calculations.

Function	Calculation range
$1/(x + y\mathrm{i})$ $(x + y\mathrm{i})^{-1}$	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$ Note: $(x + y\mathrm{i}) \neq 0$
$(x + y\mathrm{i})^2$	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$ $\lvert xy \rvert < 5\times10^{99}$

Function	Calculation range
ln $(x + y\mathrm{i})$ log $(x + y\mathrm{i})$ $\log_2 (x + y\mathrm{i})$ $\sqrt{(x + y\mathrm{i})}$	$\lvert x \rvert < 1\times10^{50}$ $\lvert y \rvert < 1\times10^{50}$ $\lvert y/x \rvert < 5\times10^{100}$
$e^{(x + y\mathrm{i})}$	$\lvert x \rvert < 230{,}25850929940456841$ $\lvert y \rvert < (\pi/180)\times10^{20}$
$10^{(x + y\mathrm{i})}$	$\lvert x \rvert < 100$ $\lvert y \rvert < (\pi/180)\times10^{20}$
$2^{(x + y\mathrm{i})}$	$\lvert x \rvert < 332{,}19280948873623479$ $\lvert y \rvert < (\pi/180)\times10^{20}$

Function	Calculation range
$(x + y\mathrm{i})^{(a + b\mathrm{i})}$	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$ $\lvert a \rvert < 10^{100}$ $\lvert b \rvert < 10^{100}$
$(a + b\mathrm{i})\sqrt{(x + y\mathrm{i})}$ $\sqrt[3]{(x + y\mathrm{i})}$	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$ $\lvert a \rvert < 10^{50}$ $\lvert b \rvert < 10^{50}$
sin $(x + y\mathrm{i})$ cos $(x + y\mathrm{i})$	$\lvert x \rvert < (\pi/180)\times 10^{20}$ $-227{,}95592420641052271 \leq y \leq 230{,}25850929940456840$
tan $(x + y\mathrm{i})$ cot $(x + y\mathrm{i})$	$\lvert x \rvert < (\pi/360)\times 10^{20}$ $-227{,}95592420641052271 \leq y \leq 230{,}25850929940456840$

Function	Calculation range
sec (x + yi) csc (x + yi)	$\lvert x \rvert < (\pi/360)\times10^{20}$ $-113{,}97796210320526136 \le y \le 115{,}1292546497022842$
$\sin^{-1}$ (x + yi) $\cos^{-1}$ (x + yi)	$\lvert x \rvert < 10^{25}$ $\lvert y \rvert < 10^{25}$
$\tan^{-1}$ (x + yi)	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$
$\cot^{-1}$ (x + yi) $\sec^{-1}$ (x + yi) $\csc^{-1}$ (x + yi)	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$ Note: (x + yi) ≠ 0
sinh (x + yi) cosh (x + yi)	$-227{,}95592420641052271 \le x \le 230{,}25850929940456840$ $\lvert y \rvert < (\pi/180)\times10^{20}$
tanh (x + yi)	$-113{,}97796210320526136 \le x \le 115{,}1292546497022842$ $\lvert y \rvert < (\pi/180)\times10^{20}$

Function	Calculation range
$\sinh^{-1}(x + y\mathrm{i})$	$\lvert x \rvert < 10^{25}$ $\lvert y \rvert < 10^{25}$
$\cosh^{-1}(x + y\mathrm{i})$	$\lvert x \rvert < 5\times10^{49}$ $\lvert y \rvert < 5\times10^{49}$
$\tanh^{-1}(x + y\mathrm{i})$	$\lvert x \rvert < 10^{50}$ $\lvert y \rvert < 10^{50}$

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