

F R E E 8 5

SCIENTIFIC GRAPHING CALCULATOR

Free85 Getting Started Manual

For firmware 3.0 · Second Edition

chriswilson2020.github.io/Free85

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Free85 Getting Started Manual

Welcome

Free85 is a scientific graphing calculator that runs in your browser. It is a complete, independently written firmware of original Z80 code, running on a faithful emulation of a TI-85-compatible pocket calculator.

Free85 is clean-room software. Everything in it (the firmware, the font, the screen artwork, the tests, and this manual) was written from scratch for this project. It contains no Texas Instruments ROM code, disassembly, fonts, artwork, or binary tables. The TI-85 is referenced only to describe the hardware profile the firmware runs on; the project is not affiliated with or endorsed by Texas Instruments. Because the internals are original, Free85 makes no promise of compatibility with TI programs, files, tokens, ROM calls, or internal data structures. What it does promise is that every physical key, every shifted function printed above a key, and every reachable menu leads to a real, working feature.

Free85 is open source under the MIT License. See the `LICENSE` file for the licence text and `NOTICE.md` for the project notices.

This manual gets you from a blank screen to confident everyday use: running the calculator, understanding the keyboard and display, doing your first calculations, adjusting modes, and finding functions in the catalog. When you want depth (graphing, statistics, programming, and everything else), the companion Guidebook covers each subject in its own chapter. The final section of this manual maps out where to go.

The hardware at a glance

The machine Free85 targets is a Z80 processor at 6 MHz driving a 128 by 64 pixel monochrome LCD, with eight 16 KiB ROM pages (131,072 bytes in all), 32 KiB of RAM, and a keyboard of 49 matrix keys plus a separate **ON** key.

Running Free85

The easiest way to use Free85 is the browser calculator published from this repository by GitHub Pages. It lives at <https://chriswilson2020.github.io/Free85/> and is also linked from the repository README in case the address changes. Open the page and the calculator is ready to use, no installation at all.

To run it on your own machine you need Node.js 24 or newer. From the repository root:

```
npm run dev
```

Then open <http://localhost:3000/> in a browser. The bundled open-source FREE85.ROM loads automatically, and the page also lets you select another compatible 128 KiB ROM if you have one.

There is also a quick terminal preview that boots the machine, presses any keys you list, and prints an ASCII rendering of the LCD:

```
npm run run:free85 -- GRAPH
```

This is handy for scripting and for checking behaviour without opening a browser. The key names it accepts are the physical key names used throughout this manual, such as ENTER, 2ND, GRAPH, and F1.

The keyboard

The keyboard has fifty keys arranged in a few zones. Once you know the zones, your fingers find things quickly.

- **Soft keys.** **F1** **F2** **F3** **F4** **F5** sit directly under the screen. They have no fixed meaning of their own: they select whatever five labels are currently shown along the bottom row of the display. When the labels change, the keys change with them.
- **Navigation and modifiers.** The next two rows share the cursor pad on their right-hand side: the first row holds **2nd**, **EXIT**, and **MORE** beside the **▲** and **▼** keys, and the second holds **ALPHA**, **x-VAR**, and **DEL** beside **◀** and **▶**. **EXIT** backs out one level; **2nd** **EXIT** is QUIT, which jumps straight back to the home screen.

- **Application keys.** **GRAPH**, **STAT**, **PRGM**, **CUSTOM**, and **CLEAR** open the major applications: graphing, statistics, programming, your custom menu, and clearing the entry line.
- **Function rows.** **LOG**, **SIN**, **COS**, **TAN**, **^**, then **LN**, **EE**, **(**, **)**, **÷**, then **x²** beside the digit pad. Each carries a shifted function printed above it and, on most keys, a letter for alpha entry.
- **Digit pad.** The digits, decimal point, **(-)** for negative numbers, the arithmetic operators down the right-hand side, **STO▶** for storing variables, and **ENTER** in the bottom corner.
- **The **ON** key.** A separate key that wakes the calculator or interrupts a running operation; **2nd** **ON** turns it off.

How **2nd** works

2nd is a one-shot modifier. Press it once, and the *next* key you press performs the shifted function printed above that key instead of its normal one. For example, **^** normally types the power operator, but **2nd** **^** types PI. Try it: press **2**, then **2nd** **^**, then **ENTER**, and the calculator evaluates 2PI to 6.2831853071796. The modifier applies to exactly one keypress and then switches itself off.

How **ALPHA** works

ALPHA is the letter modifier. Most keys have a letter assigned to them: **LOG** is A, **SIN** is B, and so on through the keyboard to **.** for Z, with **x-VAR** providing x. Press **ALPHA** once and the next key types its letter: **ALPHA** **LOG** types A.

Press **ALPHA** twice and letter entry locks: the status line shows LOCK, and every key types its letter until you press **ALPHA** again to unlock. For example, **ALPHA** **ALPHA** **SIN** **ALPHA** **1** types B1 (the lock typed B, the third **ALPHA** released it, and **1** went back to being a digit).

Lowercase letters exist too. **2nd** **ALPHA** selects lowercase letter entry; then **ALPHA** followed by a letter key types the lowercase letter. For example, **2nd** **ALPHA** **ALPHA** **SIN** types b.

What **MORE** does

Menus in Free85 show at most five choices at a time, one per soft key, and **MORE** pages to the next set. In the MATH menu, for example, the first page offers ABS(, SQRT(, FACT(, NPR(, and NCR(; pressing **MORE** brings the next five, starting with

SINH(and COSH(. Keep pressing **MORE** to cycle through all the pages. The same paging works on any row of soft labels, including the home screen's own menu row.

Keys worth memorising

Key	Normal	With 2nd
ENTER	Evaluate the entry	ENTRY: recall the previous entry
(-)	Unary minus	ANS: insert the previous answer
CLEAR	Clear the entry or dismiss an error	TOLER: change the numerical tolerance
EXIT	Back out one level	QUIT: return home
MORE	Next menu page	MODE: system mode screen
DEL	Delete at the cursor	INS: toggle insert/overwrite
ALPHA	Letter entry (twice to lock)	Lowercase letter entry
CUSTOM	Your custom menu	CATALOG: every callable function
STO▶	Store to a variable	RCL: recall a variable
GRAPH	The graph screen	SOLVER: equation solver

Every key also has a second function and often a letter, far more than fits in one table. Guidebook appendix B lists the complete map of all fifty keys with their normal, shifted, and alpha meanings.

The screen

Switch the calculator on and you see the home screen:

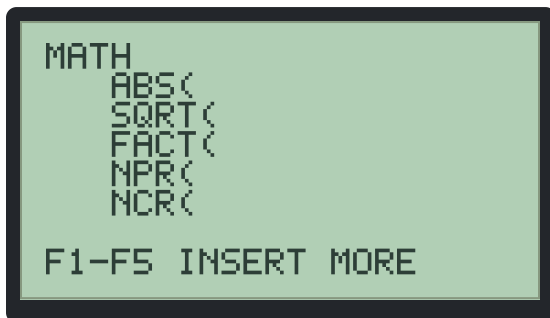


The Free85 home screen after switching on

Reading from the top:

- **Status region.** The top line shows the calculator's current state at a glance: the angle mode (RAD or DEG) and display format (AUTO, SCI, ENG, or FIX) on the left, and the editor state on the right (INS for insert mode, OVR for overwrite, and LOCK when alpha lock is on).
- **Title banner.** FREE85 HOME tells you which screen you are on.
- **Version banner.** VERSION 3.0.0 names the firmware release and disappears as soon as you type.
- **Entry line.** The underscore is the cursor. Whatever you type appears here.
- **Result area.** The middle of the screen. After you press **ENTER** the result appears here, introduced by =.
- **Soft-menu labels.** The bottom row names what **F1** through **F5** currently do. On the home screen these open the main menus: MATH, GRF, VAR, MEM, and SYS, with a second page under **MORE**.

Menus and editors take over the screen when you open them. Press **F1** on the home screen and the MATH menu appears, listing five functions with a hint line at the bottom:



The MATH menu opened with F1

Here F1-F5 INSERT MORE means: press the soft key matching a listed item to insert it into your entry, or press **MORE** for the next page. **EXIT** takes you back to the home screen with your entry untouched.

Other screens work similarly. Press **GRAPH** and the calculator draws the graph screen: axes and grid dots. Press **MORE** on the graph screen and the table of values opens, with columns for Y1, Y2, and Y3 and soft labels UP DN GRAPH EXIT. Full-screen dialogs, such as error messages and the mode screen, tell you on-screen which keys they respond to. Equations themselves are typed on the home entry line; the Guidebook's graphing chapters explain the workflow.

First calculations

Time to calculate something. From the home screen, press:

2 **+** **3** **ENTER**

The entry line shows 2+3 and the result area answers = 5:



Entering 2+3 and pressing ENTER

Notice that the expression stays on the entry line after evaluation. That is deliberate: you can keep typing to extend the expression and press **ENTER** again, or press **CLEAR** to start fresh.

The previous answer

The **(-)** key's shifted function is **ANS**, the previous answer. After the calculation above, press **CLEAR** to empty the entry line, then:

2nd **(-)** **+** **1** **0** **ENTER**

The entry line reads **ANS+10** and the result is = 15: the 5 from before, plus ten. **ANS** can appear anywhere in an expression, as many times as you like, and always means the most recent numeric result.

Recalling the previous entry

The **ENTER** key's shifted function is **ENTRY**. Press **CLEAR** to empty the line, then **2nd** **ENTER**, and the previous entry, 2+3, reappears with the cursor at the end, ready to edit and re-evaluate.

Editing

The cursor keys move along the entry line, and **DEL** deletes the character just before the cursor position. For example, type **1** **2** **3**, press **◀** once, and press **DEL**: the 2 disappears, leaving 13.

By default the editor is in insert mode (the status line shows **INS**), and typing pushes existing characters to the right. With 13 on the line, press **◀** and type **2**: the line becomes 123. Press **2nd** **DEL** to toggle overwrite mode instead; the

status line changes to OVR, and typing replaces the character under the cursor, so the same **◀ 2** on 13 then produces 12. Press **2nd DEL** again to return to insert mode.

When something goes wrong

Errors are full-screen and polite. Type **1 ÷ 0 ENTER** and a message screen replaces the home screen. It shows three lines: the error name DIVIDE BY ZERO, the hint CLEAR OR EXIT beneath it, and EXIT BACK at the bottom, telling you that **EXIT** returns you to your entry. The name is worth reading rather than glancing past: SYNTAX ERROR means the machine could not read what you typed, while DIVIDE BY ZERO, DOMAIN ERROR, NUMERIC OVERFLOW and PRECISION LOST all mean it read you perfectly well and the answer does not exist or cannot be trusted. Appendix C of the Guidebook lists them all. Press **CLEAR** or **EXIT** and you are back on the home screen with 1/0 intact and the cursor at the end, so you can fix the mistake instead of retyping it.

Modes

Press **2nd MORE** to open the SYSTEM MODE screen:



The system mode screen

Three settings are shown, and the soft keys ANG FMT - + MEM adjust them:

- **Angle.** ANGLE RAD or ANGLE DEG. Press **F1** (ANG) to toggle between radians and degrees. The choice is echoed in the home-screen status line and affects all trigonometric functions.
- **Display format.** Press **F2** (FMT) to cycle FORMAT through four settings:
 - AUTO: ordinary decimal output, switching to an exponent for values outside the compact display range;

- SCI: one digit before the decimal point and an explicit exponent;
- ENG: one to three digits before the point and an exponent divisible by three;
- FIX: a fixed number of decimal places with half-up rounding.

While FIX is selected,  and  change the number of decimal places, from FIX 0 up to FIX 11. The format changes how results are displayed, not the precision the calculator stores.

- **Contrast.** CONTRAST 16 by default.  (–) lowers the setting one step at a time and  (+) raises it; the number updates as you press.

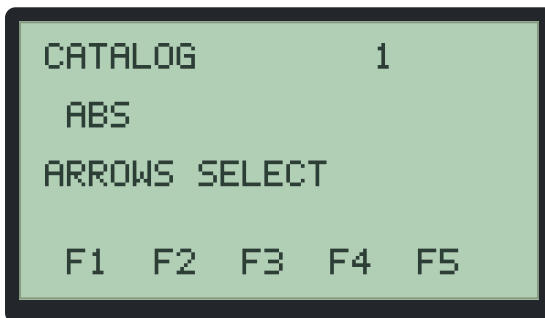
 (MEM) opens the memory browser from here, showing the object count and letting you inspect and delete stored objects. Press  to leave the mode screen and return home.

Number-base display

Free85 can show integer results in other bases. After calculating an integer, say 42, press   to open the NUMBER BASE screen. Its soft keys DEC HEX OCT BIN display the previous answer in the chosen base; press  (HEX) and the screen shows 0x002A. Base entry, two's-complement behaviour, and the Boolean word operations are covered in Guidebook chapter 10, *Number Bases and Boolean Operations*.

The catalog and custom menu

Every function you can call lives in one alphabetical list: the catalog. Press   to open it:



The catalog, opened with 2nd CUSTOM

The header shows the page number and the current item (the list starts at ABS), with the hint ARROWS SELECT. Use  and  to move through the list, and press  to paste the highlighted item into your entry line. For example,      pastes ACOSH(at the home screen. Press  to leave the catalog without choosing anything.

The catalog and the custom menu work as a pair. While an item is highlighted in the catalog, pressing one of  through  assigns it to that custom-menu slot; the screen confirms with a message such as ASSIGNED F2.

Press  (unshifted) to open your custom menu. Its five slots come preloaded with ABS, EXP, LIS, SQR, and STA, shown as soft labels, and the screen explains itself: F1–F5 RUN SLOT and MORE: CATALOG. Pressing a soft key inserts that slot's function (  pastes ABS(), and pressing  jumps to the catalog so you can reassign slots. Once you have arranged your five most-used functions here, they are always two keypresses away.

Where next

This manual has walked you through the front door; the Free85 Guidebook is the full tour, one chapter per subject:

1. **Operating the Calculator:** modes, the editor, and previous entries.
2. **Variables and Stored Data:** storing, recalling, and managing named data.
3. **Mathematics, Calculus, and Comparisons:** the full function set and the fourteen-digit arithmetic behind every result, with worked examples throughout.
4. **Cartesian Graphing, Drawing, Formats, and Persistence:** plotting, drawing, graph formats, and what the calculator remembers of a plot.
5. **Polar Graphing:** curves in polar coordinates.
6. **Parametric Graphing:** curves driven by a parameter.
7. **Differential-Equation Graphing:** graphing solutions of differential equations.
8. **Physical and User Constants and Conversions:** built-in values and unit conversions.
9. **Strings and Characters:** text values and the character palette.
10. **Number Bases and Boolean Operations:** binary, octal, and hexadecimal display, entry, and word logic.

11. **Complex Numbers:** arithmetic and functions beyond the reals.
12. **Lists:** ordered collections and list arithmetic.
13. **Matrices and Vectors:** linear-algebra objects and their operations.
14. **Equation, Polynomial, and Simultaneous Solving:** root finding for any expression, polynomials up to degree four, and linear systems of up to four unknowns.
15. **Statistics and Statistical Plots:** column summaries, least-squares regression in linear, logarithmic, exponential, power, and polynomial forms, and the scatter, connected xy-line, histogram, and box plots.
16. **Calculator Programming:** the on-calculator programming environment.
17. **Worked Application Examples:** complete applications, step by step.
18. **Memory Management:** browsing, inspecting, and deleting stored objects.
19. **Calculator Linking:** transferring stored objects between calculators and backing up a whole machine over the link port.

Four appendices round it out: appendix A is the command and function catalog, appendix B the complete key map of all fifty keys, appendix C the system variables and error messages, and appendix D records feature status across the release. Pick the chapter that matches what you want to do next, and enjoy the calculator.

FREE85

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<https://chriswilson2020.github.io/Free85/>

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