

# Minimum Squares Line

Luís Gonçalves

[luisgo@luisgo.pro](mailto:luisgo@luisgo.pro)

<https://luisgo.pro#hobbies>

23<sup>rd</sup> March 2026

## I. ABOUT THE PROGRAM

The program helps the plotting of points  $(x, y)$  and the drawing of the Least Squares Line and the corresponding confidence lines at 90% and 95% on any scale units (millimeter, inches etc) paper (paper shown in Figure 1 for millimeters, PDF included).

This program is mainly useful for first- and second-year university students in science and engineering, as in those years there are laboratory works that require drawing linear relationships in which the slope of the line is a parameter to be determined.

The following parameters must be entered for both the X axis (horizontal) and the Y axis (vertical) (Figure 2):

- Choose whether the scale is logarithmic or linear.
- The lower limit of the scale in the units measured in the experiment.
- The upper limit of the scale in the units measured in the experiment.
- The number of scale units on the sheet between the lower and upper limits.

Figure 2 shows an example of the settings: X axis with a logarithmic scale, lower limit 0.1, upper limit 10 (2 decades), and 200 scale units (100 scale units per decade).

As the values  $(x, y)$  are entered (up to a maximum of 100 points), the program computes and displays the corresponding scale units for  $x$  and  $y$  in order to plot the points on the sheet (Figure 3).

If a scale is logarithmic, the values  $(x$  and/or  $y)$  used to compute the Least Squares line are the values in the scale units (only in this way does the line make sense, since exponential values are not suitable for computing a linear fit).

The resulting Least Squares line has the form  $y = mx + b$ , where  $m$  is the slope and  $b$  is the y-intercept. Four points of the line are computed in the scale units in order to draw it (Figure 4): two points at the extremes of the X scale and one point at 1/4 of the X scale and other at 3/4 of the X scale.

The slopes of the lines for confidence intervals of the slope of 90% and 95% are explained in the following link:

<https://chatgpt.com/share/699a0dbc-34cc-8002-ab4c-053d020d82b6>

Who does not want to follow links can make the following question in ChatGPT:

Consider that there are a set of points  $(x, y)$  and correspondent Minimum Square line parameters (slope and y intersect). How I compute the 90% and 95% confidence slopes of the Minimum Square line?

The y-intersect of each confidence line, given the slope  $m_0$ , are found with  $b_0 = \bar{y}_i - m_0 \bar{x}$ .

Figure 5 and Figure 6 show the results of the Lines of confidence of the slope at 90% and 95%. To generate these results is needed to input at least 3 points. The results are perfect due to the input of values without offset from the Minimum Square Line.

Four points of each line are computed in the scale units in order to draw it (Figure 5 and Figure 6): two points at the extremes of the X scale and one point at 1/4 of the X scale and other at 3/4 of the X scale (as Minimum Square Line).

## II. HOW TO RUN THE PROGRAM

The program was written in BASIC and compiled with the Softek BASIC Compiler. The compiled version of the program is provided. The program was tested using the emulator "The Spectrum" from Retro Games. It works on all Sinclair platforms (ZX 48K, 128K, etc.) within "The Spectrum".

However, the Softek compiler does not work with the firmware that comes with "The Spectrum". The provided zip file must be extracted to the root directory of the USB pen drive used in "The Spectrum". It

already contains the original ZX Spectrum firmware. After extracting the zip file, the original firmware of the ZX Spectrum is automatically used.

The firmware files are located in the directory */THESPECTRUM/roms*. The files in that directory must be renamed if you wish to revert to the original "The Spectrum" firmware after using the program.

You can confirm that "The Spectrum" is using the original ZX Spectrum firmware because, at startup, the Sinclair message appears instead of the Retro Games message.

The procedure is as follows:

- Decompress the zip file to the root directory of the USB pen drive.
- Select the media file *Line.tap* in "The Spectrum". Enter. The program loads automatically.

A WAV file is also provided for use with the original ZX Spectrum, although it has not been tested.

### Run on Windows

A native version of the program for Windows is included in the directory */Windows/*. It was written in C. This version permits the generation of a script for Matlab/Octave which it is a template to generate the graphic. This feature is in Beta state.

<https://octave.org/download>

The program works with Klive 1.1 (Sinclair Spectrum Emulator), also included.

<https://www.planetemu.net/php/emulateurs/?action=download&id=861>

- Options -> Video -> Window Size -> 800x600 (may be chosen another)
- See Options -> Miscellaneous (Show Spectrum Keyboard, CAPS SHIFT and SYMBOL SHIFT definition in the PC Keyboard). If you struggle with the keyboard of ZX Spectrum 48K choose, Hardware -> Spectrum +2a (+3 Basic in the menu) and (later) input character by character.
- File -> Attach Tape File (*Line.tap* or *Line.wav*)
- At the command line, type *LOAD ""*. Press Enter.
- Tape Control -> Play/Stop

Another emulators at: <https://www.planetemu.net/emulateurs/zx-spectrum/Windows>

### Run on Linux

A native version of the program for Linux is included in the directory */Linux/*. It was written in C. This version permits the generation of a script for Matlab/Octave which it is a template to generate the graphic. This feature is in Beta state.

<https://octave.org/download>

Choose one emulator.

<https://www.planetemu.net/emulateurs/zx-spectrum/Linux>

### Run on Mac

Choose one emulator.

<https://www.planetemu.net/emulateurs/zx-spectrum/MacOS>

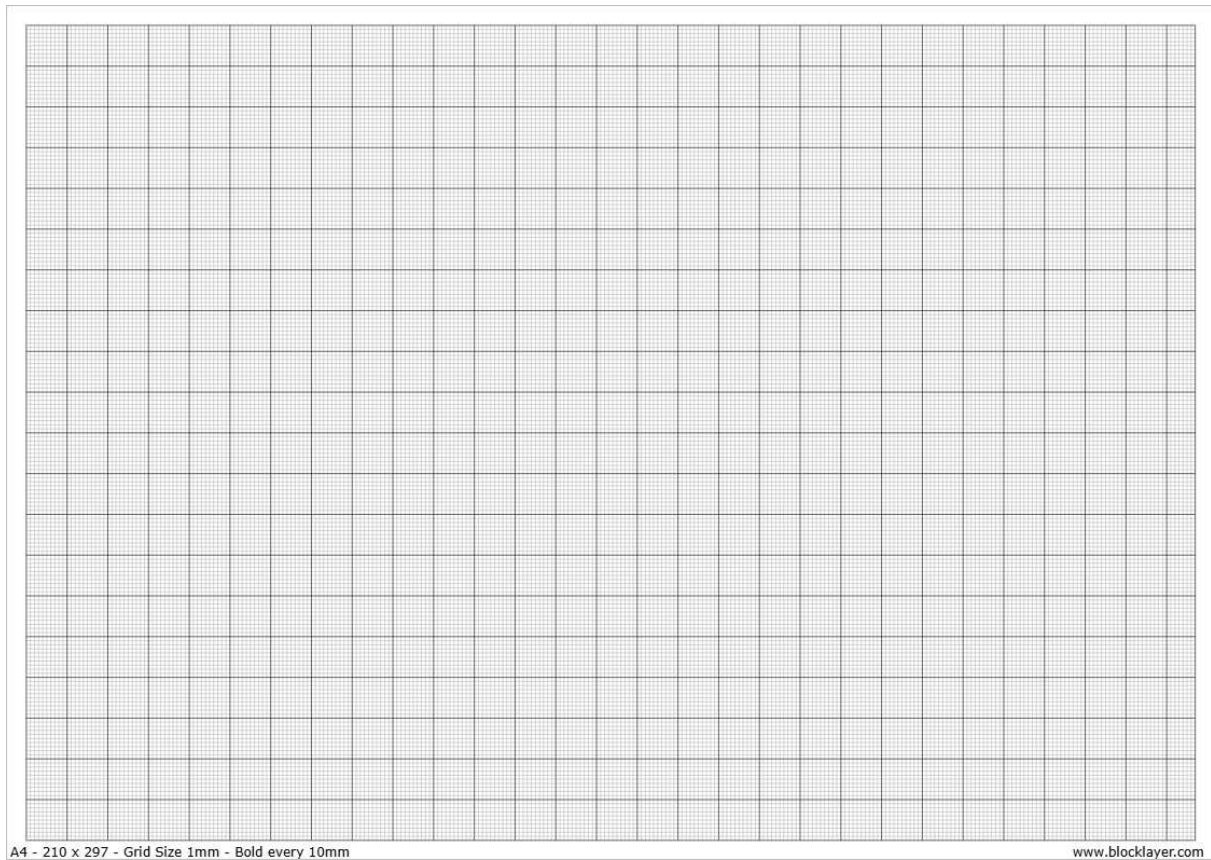


Figure 1

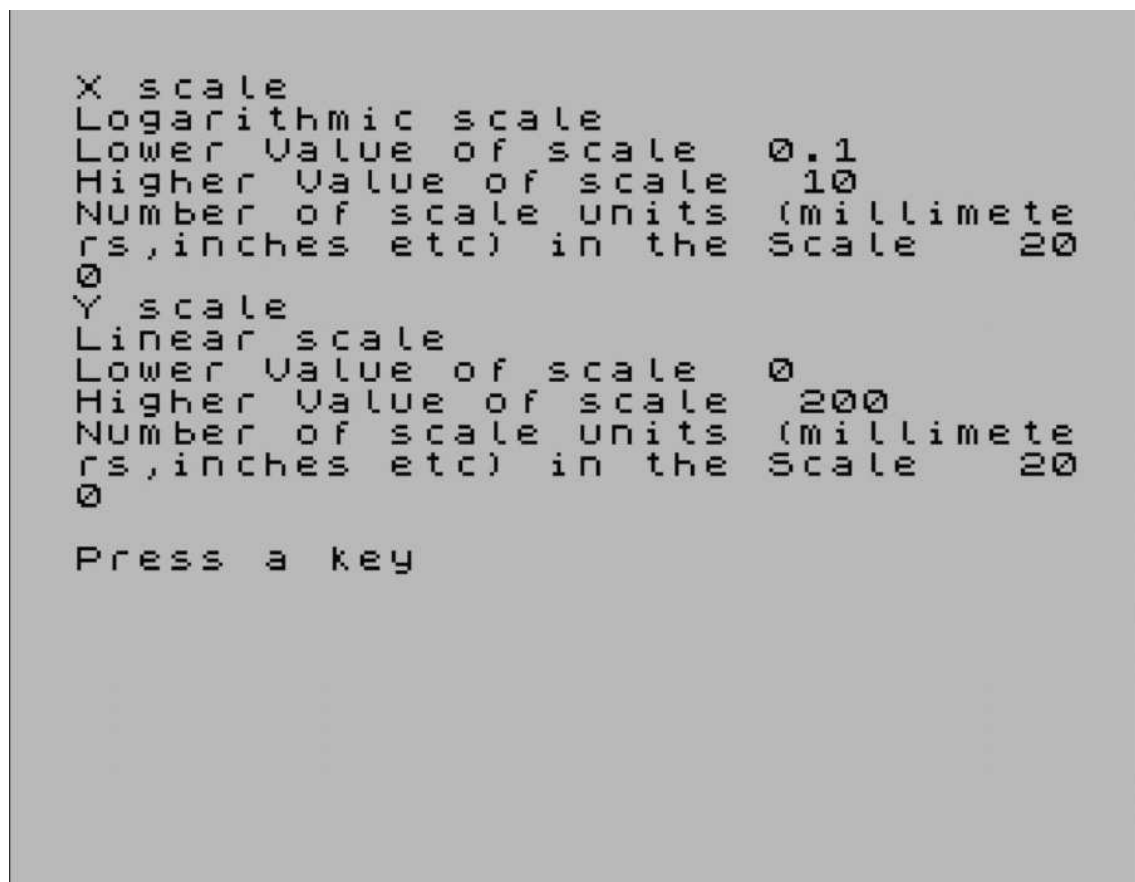


Figure 2

```

Point 1
Value X  0.1      Scale Units  0
Value Y  0        Scale Units  0
C key to continue inputing, K key
to input again the last point
Point 2
Value X  1        Scale Units  100
Value Y  100      Scale Units  100
A key to computing the line, C k
ey to continue inputing, K key t
o input again the last point
Point 3
Value X  10       Scale Units  200
Value Y  200      Scale Units  200
A key to computing the line, C k
ey to continue inputing, K key t
o input again the last point

```

Figure 3

```

For Logarithmic scales the value
s considered for the computing o
f the lines are the scale units
values
Slope of the line 1
y intersect of the line 0
Left point of the line in scale
units
x1 0  y1 0
Right point of the line in scale
units
x2 200  y2 200
1/4 scale point of the line in s
cale units
x3 50  y3 50
3/4 scale point of the line in s
cale units
x4 150  y4 150

Press C to continue
Press B to begin

```

Figure 4

```
Confidence Lines 90%
Slope 1 y-inter 0
x1 0 y1 0
x2 200 y2 200
x3 50 y3 50
x4 150 y4 150
Slope 1 y-inter 0
x1 0 y1 0
x2 200 y2 200
x3 50 y3 50
x4 150 y4 150
```

```
Press C to continue
Press B to begin
```

Figure 5

```
Confidence Lines 95%
Slope 1 y-inter 0
x1 0 y1 0
x2 200 y2 200
x3 50 y3 50
x4 150 y4 150
Slope 1 y-inter 0
x1 0 y1 0
x2 200 y2 200
x3 50 y3 50
x4 150 y4 150
```

```
Press C to continue
Press B to begin
```

Figure 6