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# microMathematics

## version 1.24

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The microMathematics is the world's first mathematical calculator on Android oriented around a spreadsheet that allows live editing of mathematical identities combined with highly accurate computations.

It is based on a powerful touch-screen editor that allows users to create and manipulate naturally readable worksheets containing all basic mathematical notations.

microMathematics supports basic level of mathematical calculations. If you find microMathematics useful or need more mathematics (3D plots, summation and product operations, derivative and definite integrals, logical operators, units), please consider purchasing premium version to support further development.

## 1 How To Use

This app is a powerful calculation software in a worksheet format. The worksheet can be freely edited, stored on SD card, opened from SD card and exported into an image or LaTeX format.

Worksheet is a mathematical document that contains text, formulas and plots. It supports live editing of typeset mathematical notations and its automatic computation.

### Basics

The interface contains worksheet area in the center, tool bar at the bottom, action bar at the top, and floating action button(s) towards bottom right.

The content of the action bar depends on the screen resolution and device orientation. The buttons can

be shown in action bar directly, or placed within "three-dots" menu.

Following objects can be inserted into worksheet: equations, result views, plots, text fragments and images. These are inserted by using the buttons in the tool bar, or the "New element" button in the action bar.

### 1.1 Editing

Almost all available objects contain several editable fields. To edit the field use the symbols and functions on the tool bar.

All symbols can also be entered from the keyboard. Long click on a symbol's button for hint about which keyboard symbol (or combination) corresponds to it.

Using long click on a term you can select the term. A context menu appears at the top. The selected term can be deleted, copied to clipboard, pasted from clipboard or an other operator or function can be inserted using buttons from the tool bar or keyboard. The button "Insert in the left of selected" from the context menu switches the insertion mode: before or after the selected term. "Expand selection" button allows to expand the selected area.

The "Undo" command is available in the action bar. It erases the last change done to the document and reverts it to an older state:



## 1.2 Equation

An equation defines a numerical constant, an interval, or a function. To create an equation, use the "New element" button in the action bar



or the "Add equation" button from the tool bar:



An equation with two empty fields appears. These fields shall be filled:

$\square := \square$

The equation name is given in the left field. The name shall contain letters or digits only and will be used in other objects in order to reference this equation.

From the action bar, you can open "Document settings" dialog window:



Depending on the parameter "Allow to re-define equations" in this dialog, there are two usage modes:

- a) if re-definition is not allowed, the equation name shall be unique within whole worksheet and the equation can be used both before and after its definition,
- b) if re-definition is allowed, you can define more than one equation with the same name. If such an equation is referenced, the last version defined before the caller equation will be used.

### 1.2.1 Constant

If the equation name does not contain any argument in brackets, it defines a constant or an interval:

$$N := 200 \quad Sq2 := \sqrt{100} \quad Pi2 := \frac{\pi}{2}$$

In the last example, a built-in constant pi was used. Currently, the following built-in constants are available:

$$\pi = 3.14159 \quad pi = 3.14159 \quad e = 2.71828$$

A previously defined constant can also be used:

$$NPi2 := N \cdot Pi2$$

You can also use the symbol "i" as imaginary unit in order to define a complex number:

$$z := 5 + 3i$$

### 1.2.2 Interval

An interval type equation defines a variable that is changed from a given minimum value up to a given maximum value with defined increment. This variable can be used as a function plot argument or as a parameter to build a function value table.

To define an interval, put a valid name on the left side of an empty equation. On the right side of this equation, put either a symbol ":", or click the button "Equidistant interval" from the tool bar:



Here, the first element is the interval start point, the next element is the second point, and the last element is the interval end point:

$$x := [0, 0.1 .. 10]$$

The interval elements shall be accessed by index:

$$x(0) = 0.0 \quad x(1) = 0.1 \quad x(100) = 10.0$$

The increment is the difference between two neighbours values:

$$x(2) - x(1) = 0.1$$

For example, we can define an equidistant interval that contains N points distributed with increment "dy" where the interval start is zero as follows:

$$dy := 0.05 \quad y := [0, dy .. dy \cdot N]$$

### 1.2.3 Function

A function is a relation between one or more arguments and a set of permissible outputs with the property, that each argument value (real or complex) or arguments combination is related to exactly one output.

The function name and the function argument in brackets are given on the left side of an equation. It is not necessary to define the argument in the worksheet previously, you can define it as you want, but using letters or digits only:

$$f(t) := \sin(t) \cdot \cos(t) / 2$$

$$w(z) := e^{2i \cdot \pi \cdot z}$$

$$H(x, y) := \sqrt{x^2 + y^2}$$

$$g(x, y) := \frac{\sin(H(x, y))}{H(x, y/2) + 1}$$

The right side of the function contains a mathematical formula how to calculate the function. If this formula does not contain the declared function argument, such a function will be interpreted as a constant.

You can also use on the right side other built-in or previously defined functions. To insert a function enter its name, click the left bracket symbol "(" and then enter its argument. This argument can also be a formula, which contains any other operations and functions.

The document "functions\_overview.mmt", stored within the "Resources of microMathematic", provides the list of all available functions.

## 1.3 Result View

This element is aimed to represent a calculation result as a number or a table. To add this element, use the "New element" button on the action bar or the "Add result view" button from the tool bar:



An equation with two fields appears, where the left field shall be filled:

$$\square = \square$$

The left term contains a formula to be calculated and the right term is the calculation result. The result will be shown when you press the floating button "Calculate".

Within the left term you can use any constants and functions defined previously as well as any built-in functions:

$$e^\pi \cdot f(NPi2) = 2.27286E - 14$$

### 1.3.1 Constant result

If the left part does not contain any "interval-like" variables, the calculation result is just a real or complex number:

$$y(N - 1) - y(0) = 9.95$$

$$\Re(z) = 5.0 \quad \Im(z) = 3.0 \quad |z| = 5.83095$$

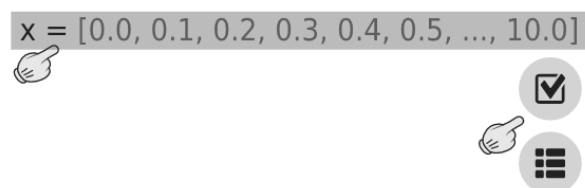
$$\sqrt{\sin\left(\frac{3}{2} \cdot \pi\right)} = 0.0 + 1.0i$$

### 1.3.2 Intervals

If the left part contains an interval variable, the calculation result is a vector of values corresponding to this interval. Due to free space limit on the display, only the first six and the last elements of the vector will be displayed:

$$x = \begin{bmatrix} 0.0 \\ 0.1 \\ 0.2 \\ 0.3 \\ 0.4 \\ 0.5 \\ \dots \\ 10.0 \end{bmatrix} \quad y = \begin{bmatrix} 0.0 \\ 0.05 \\ 0.1 \\ 0.15 \\ 0.2 \\ 0.25 \\ \dots \\ 10.0 \end{bmatrix} \quad 2 \cdot y = \begin{bmatrix} 0 \\ 1/10 \\ 1/5 \\ 3/10 \\ 2/5 \\ 1/2 \\ \dots \\ 20 \end{bmatrix}$$

Number of displayed elements and the mode in which the result is displayed can be changed. Using the long click on the formula area and the context menu, select the whole formula. If the formula is selected, the floating button "Object properties" appears. If you click this button, the result properties dialog will be displayed:



The second floating button, "Details", will also appear. If you click on this button, the "Details" dialog will be displayed, where you can observe all elements of the array.

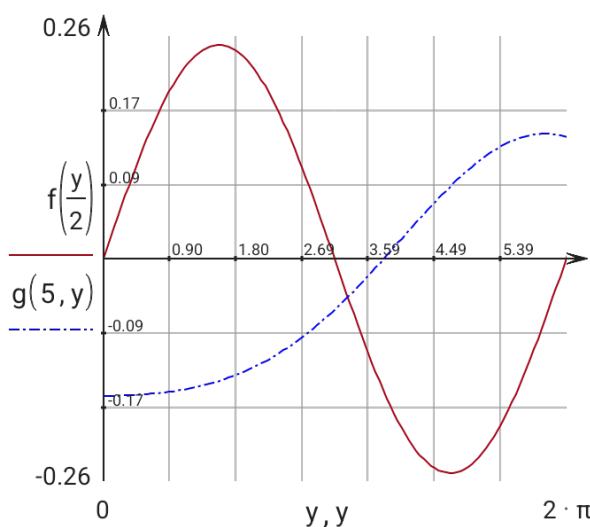
Note that the use of two or more "interval-like" variables on the left part of a result view is not allowed in this app version.

## 1.4 Function Plot

The function plot element displays a graph of a function, which depends on a single argument. To create a plot, use the "New element" button in the action bar or the "Add function plot" button from the tool bar:



Plot panel with six empty fields appears. The function to be plot shall be put in the middle-left field and the function argument in the middle-bottom field:



For more details see "Function Plot" and "Polar Function Plot" examples from the app navigation drawer.

## 1.5 Text Fragment

The text fragment element displays simple text like this one. To add a text fragment, use the "New element" button in the action bar or "Add text fragment" button from the tool bar:



If the whole text within a fragment is selected using the context menu "Select all", a floating button "Object properties" appears in the bottom-right of the screen.

If you click on this button, the "Text properties" dialog will be displayed, where you can select the text style and activate the numbering. For example, the titles in this document have the style "Subsection" with activated numbering.

## 1.6 Image

You can also insert an image from the image file. To do it, use the "New element" button from the action bar or the "Add image from file" button from the tool bar:



The "Image settings" dialog will appear. There you can select a file with the image to be inserted and set the necessary image size.

The following image formats are supported: png, bmp, gif, jpeg, svg.

If you activate the "Embedded image" flag in the "Image settings" dialog, then the image will be embedded directly in your document. Embedded image results in stand-alone, but larger document.

If the "Embedded image" flag is not set, the image file will be just referenced rather than embedded, i.e. your document references the image file outside the document. In case you move your document please do not forget to move the image file as well.

You can change the properties of an already existing image. Long click on the image area until the floating button "Object properties" appears. If you press this button, a dialog with image properties will be displayed.

## 2 Example: Function Plot

This example demonstrates how to prepare and adjust a graphical representation of a function. For example, we want to plot three different functions:

$$f(x) := 25 + 10 \cdot \sin(\sqrt{|x|})$$

$$g(x) := \frac{2}{e^{|x|/15}} \cdot f(x \cdot 50)$$

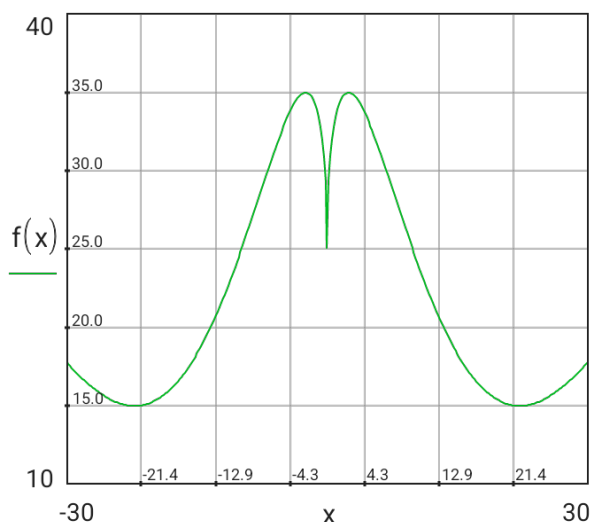
$$h(x) := \min(f(x), g(x))$$

The function argument that represents the x-values will be taken for N points within the interval [x1, x2]:

$$N := 300 \quad x1 := -30 \quad x2 := 30$$

$$x := [x1, x1 + (x2 - x1) / N .. x2]$$

After the functions and their arguments are defined, you can add the plot box using the "New element" button in the action bar or "Add function plot" button from the tool bar:

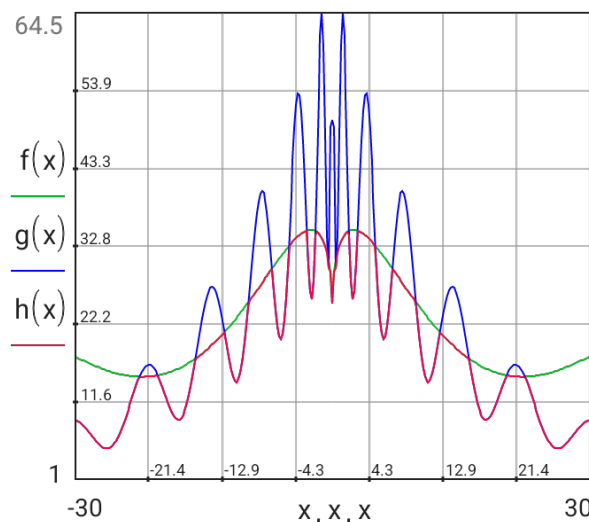
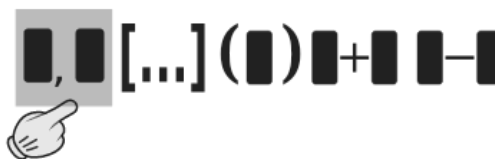


The function to be plotted will be put in the middle-left field. It can also be a built-in or previously declared function as well as a mathematical expression that contains any other operators and functions.

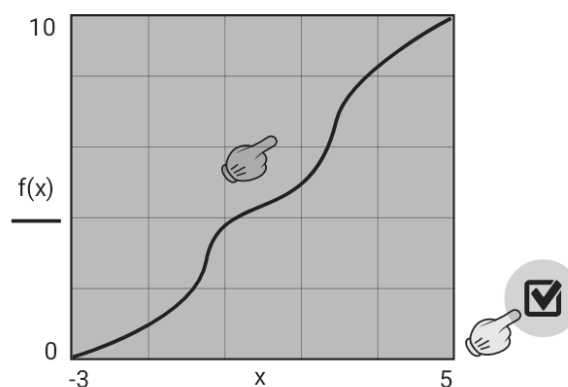
The function input, which represents the x-values will be put in the middle-bottom field. It can be a variable of interval type or a mathematical expression that contains an interval variable.

All other four fields describe the plot boundaries. If these elements remain empty, the program will calculate corresponding values automatically. However, you can edit these fields at any time and put there the values you want.

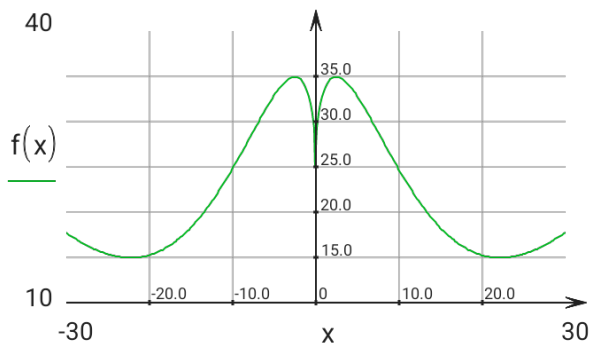
You can plot several functions on the same plot view. To add an other function, select the function (by long click in the middle-left field) after which an other function shall be added and press "Add new argument" button from the tool bar:



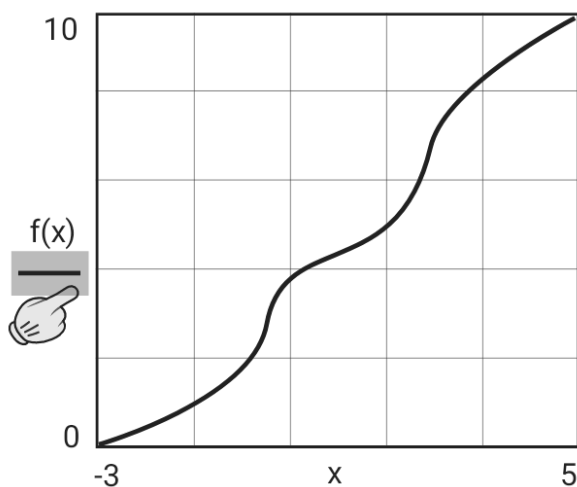
By long click on the middle of plot area, the context menu and the floating button "Object properties" will appear.



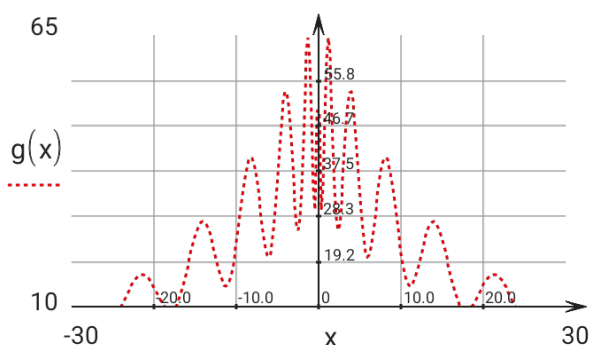
If you press this floating button, the "Plot Settings" dialog will be displayed. Here, you can change size and style of the plot area. For example, the crossed graph looks like this:



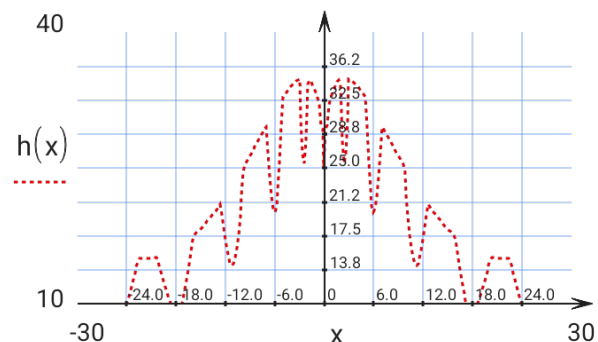
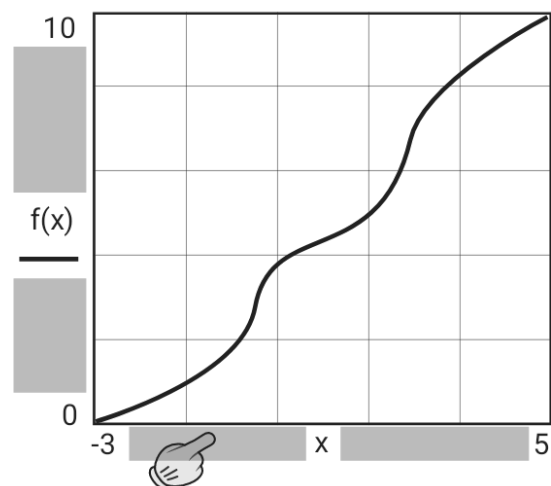
You can also change the plot line color, line width, style and value markers in the "Line Settings" dialog. It appears by long click on the line marker below the function name on the left of plot area:



For example, we can use dotted lines:



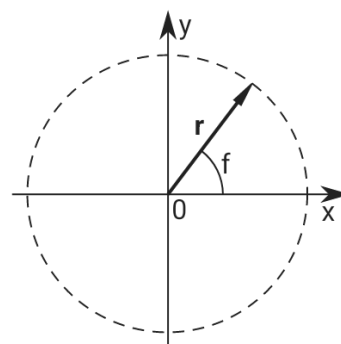
The axis scale (linear or logarithmic), number of axis labels and grid line color can be changed in the "Grid Settings" dialog. It appears by long click on the free space between the x minimum value (-30) and the argument (x) symbol or between the x symbol and the x maximum value (30) below the plot area:



To hide grid completely just set the number of grid lines to zero for both vertical and horizontal axes.

### 3 Example: Polar Function Plot

Now we plot several functions given in the polar coordinate system. Each point in this system is determined by a distance  $r$  from the origin and the angle  $f$  from the x-axis.



The angle  $f$  is our independent variable that is changed as follows:

$$f := [0.01, 0.05 \dots 300]$$

The distance  $r(f)$  is our dependent variable. Having a pair of  $f$  and  $r$ , we can transform it to the Cartesian coordinates  $x$  and  $y$  using sine and cosine functions:

$$x(r) := r \cdot \cos(f) \quad y(r) := r \cdot \sin(f)$$

### 3.1 A snail

We will define our polar function in three steps. The first expression defines a "wheel":

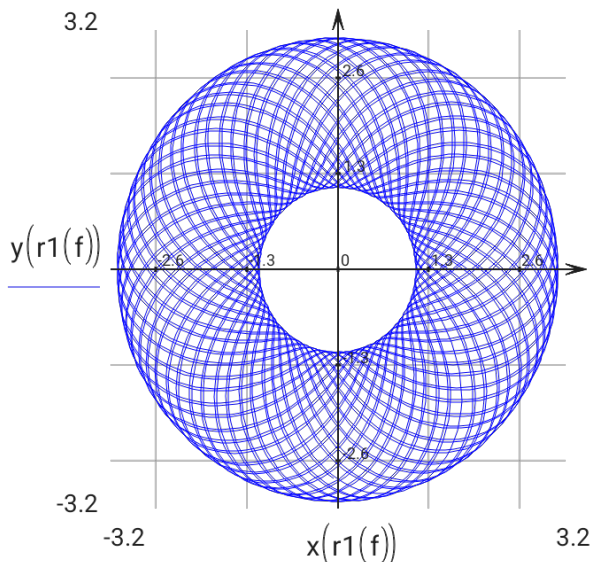
$$A := 1.1 \quad B := 1.271 \quad q := 2$$

$$r1(f) := A + 2 \cdot \sin(B \cdot f)^q$$

To plot this function, we add the plot box using the "New element" button in the action bar or "Add function plot" button from the tool bar:

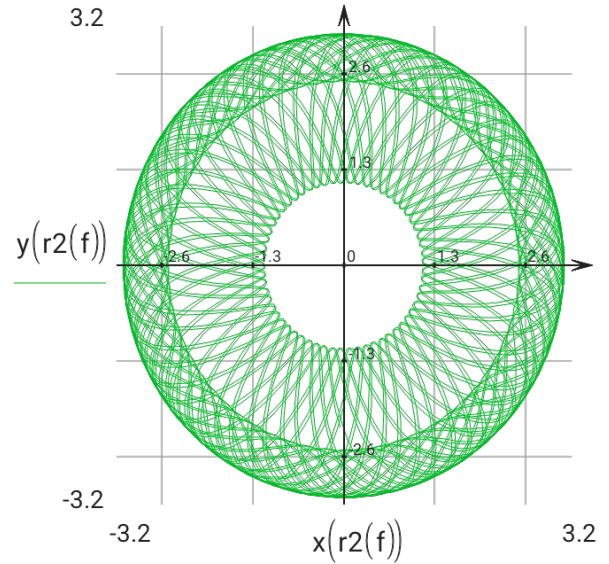


Instead of  $f$  and  $r$ , we use here previously defined rules for  $x$  and  $y$  transformation, where  $r1(f)$  is used as a symbolic argument for these rules:



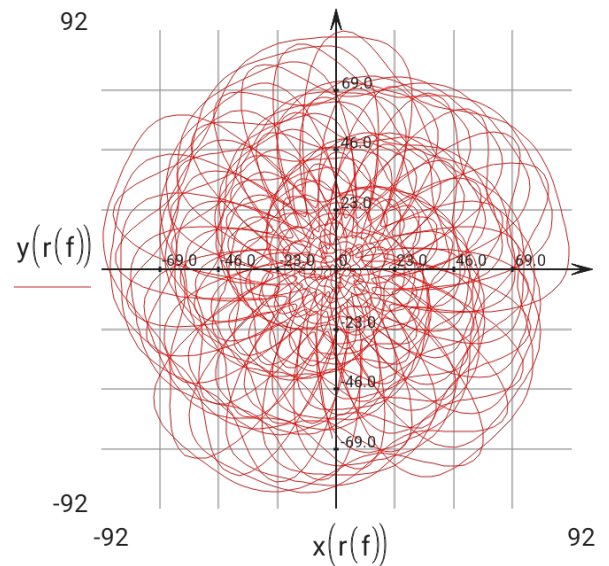
Next, we can modify this wheel as follows:

$$r2(f) := A + 2 \cdot \sin(B \cdot f + 1 \cdot r1(f))^q$$



Finally, we scale the last function  $r2(f)$  using a float to integer conversion that looks like a step function. As a result, we obtain a nice snail:

$$r(f) := r2(f) \cdot \text{floor}(f) / 10$$



### 3.2 Japanese Maple

Japanese Maple is well known for its attractive leaf shapes and colors. Such a leaf can be described mathematically and plotted as a curve in the polar coordinate system:

$$f := [0.01, 0.02 \dots 100]$$

$$x(r) := r \cdot \cos(f) \quad y(r) := r \cdot \sin(f)$$

$$s1(f) := (1 + \sin(f)) \cdot (1 - 0.9 \cdot |\sin(4 \cdot f)|)$$

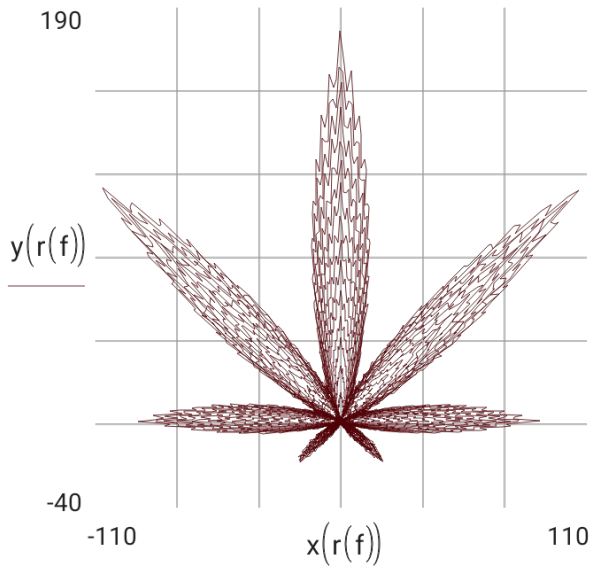
$$s2(f) := 0.9 + 0.05 \cdot \cos(200 \cdot f)$$



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$$r(f) := \text{floor}(f) \cdot s1(f) \cdot s2(f) + \text{random}(2) - 1$$



[http://en.wikipedia.org/wiki/Acer\\_palmatum](http://en.wikipedia.org/wiki/Acer_palmatum)

## 4 About

### The app icon

The app icon is generated from the following function defined in the polar coordinate system:

$$f := [0.01, 0.03 \dots 150]$$

$$s(f) := 4 + \sin(5 \cdot f) + \frac{\sin(10 \cdot f)}{2} + \frac{\sin(60 \cdot f)}{6}$$

$$r(f) := 0.9 \cdot (1 + f/50) \cdot s(f)$$

$$x(f) := r(f) \cdot \cos(f)$$

$$y(f) := r(f) \cdot \sin(f)$$

