Vande – usage notes

This is a web page for drawing graphs of functions. These notes are for version 3.

Please report bugs and send comments and suggestions to w.w.milner@gmail.com

Because of the small screen size, it would never be much use on a mobile phone, so it is intended for use on a laptop or desktop. It will work with most modern browsers, but Firefox has a bug and needs a fix, described below.

It works on Linux Ubuntu on Chrome and Firefox (with the fix)

And on Debian Mint on Opera, Chrome and Firefox.

And on Windows X on Chrome and Edge.

Table of Contents

Quick start

Click the ‘Graph an expression’ button. Click ‘Show’. See the graph of y=x sin(2x)

Change the expression if you like. ‘Hide’ hides the graph. ‘Close’ closes the dialog.

The dialog is modal, which means other clicks are ignored until it is closed.

Expression syntax

This is always a graph against x.

This is like normal maths, using (round brackets), except * is needed for multiplication. Examples are

2x+3 is written 2*x+3

sin(4x) is written sin(4*x)

$\frac{2x+1}{x-1}$ is written (2*x+1)/(x-1)

and so on.

Single lower case letters are parameters mostly set to 1 (but can be changed). e is 2.71.. and pi is π.

Built in functions

Vande knows about several functions already.

Common functions

sin, abs (absolute value), acos (inverse cosine), atan, ceil (ceiling function), exp (exponential), floor, log (natural), pow (power, so pow(x,-2) = x^{-2}), sqrt, tan, cos, acosh, asin, atanh, cbrt (cube root), cosh, sinh, tanh.

The trig functions use radians.

Less common functions

gamma(x) : gamma function

laguerre(n,x) : the nth Laguerre polynomial

fact(n) : n!

hermite(n,x) : the nth Hermite polynomial

ddx(n, exp, x) : the nth differential coefficient, of a function exp, written as a string in quotes. So for example ddx(2,"x*x*x",x) = $\frac{d^2}{dx^2}x^3$

integral(exp,x) : the definite integral of a function exp, written as a string, with the lower limit being xMin, the left-hand edge of the graph.

leg(n,x) : The nth Legendre polynomial

poch(n,x) : The Pochhammer function, the rising factorial. So poch(3,x) = x(n+1)(n+2)

sq(x) : A square wave

tri(x) : A triangular wave.

The buttons

These do as they say.

Graph an expression

This lets the user input and graph a simple expression, like x+2, as a function of x.

Vary parameters

The parameters are a to z. Apart from e, these all start at 1. This lets the users change a parameter and see the effect. For example we can plot m*x+c, then change c.

Family of curves

This draws a set of related functions, with someparameter changing. The default example plots ax^2 as a changes.

Parametric curves

The idea is that the independent vaibale is not x – in this version it is t. Then we define both x and y as functions of t, and see how x and y change as the parameter varies. The default example is

x = 2 sin (2t)

y = 3 cos (t)

which produces a Lissajous figure.

Polar co-ordinates

Instead of having y as a function of x, we have r as a function of an angle θ. We plot this as a graph by having the angle anti-clockwise around from the x axis, and r as the distance from the origin.

This uses t as the angle usually called θ.

The default example plots

r = 2 + 2 cos (4 t)

First order differential equations

This plots solutions of differential equations in the form

dy/dx =f(x,y)

with a boundary condition given by a y value when x=0.

There is also an option to display a direction field.

Function defined as a series

This plots a function defined as a series.

The terms need to use n as an index. The user can input the range of n, and an expression foreach term.

The default is $\sum_{n=1}^{100} \sin\frac{(nx)}{n}$, which approximates to a triangle wave (Fourier series)

Implicit equations

Instead of the usual y=f(x), this plots a relation between x and y defined as f(x,y) = 0.

The default is $x^2+y^2-4=0$, which is a circle radius 2 and centre at the origin.

y is not a function of x, since some x values map to 2 y values.

Integral

This shows the integral of a function.

It plots

$\int_{xMin}^{x} f(x)dx$ where xMin is the x value at the left edge of the graph, and f is the input expression.

The default expression is x/3, and xMin is -5, so we get [$x^2/6$] with limits -5 to x, which is $x^2/6$ -25/6

Hide all functions

This hides all functions except those in the function list.

Re-plot functions

This re-plots the function list.

The function list

Up to 10 functions can be defined in the table.

Each function can have a name, an expression for y in terms of x, and a colour to plot it in. It is also possible to control whether or not the function is displayed.

Click ‘Re-plot’ after editing any of this.

It is possible to use one function in the expression of another. For example we can say

f = x+1 and then

g = f(2*x) to look at the composition of functions

Function shift

In the function list, set up

f	x*x
g	f(x)+1
h	f(x+1)

See that f is a parabola, g is the same shifted ‘up’ 1 units, and that h is shifted ‘left’ 1 unit.

Change it to

f	x*x
g	f(x)+a
h	f(x+a)

then do ‘Vary parameters’ and see it works for any constant.

Try different functions for f and see it works for all.

Function stretches and shrinks

Set up:

f	x*x-1
g	a*f(x)
h	f(a*x)

See that af(x) stretches on the y axis (if a>1) and f(ax) shrinks on the x axis.

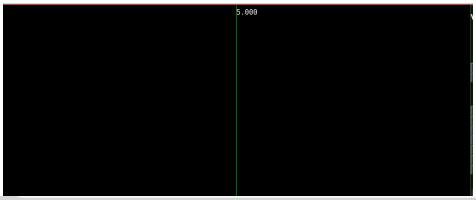
Equation solution by zoom

Suppose we want to solve an equation which has the form

f(x)=0

Usually we would do this by some algebraic method.

An alternative is to graph f, then see where it crosses the x axis. To get a more accurate answer, we can zoom in on that point.

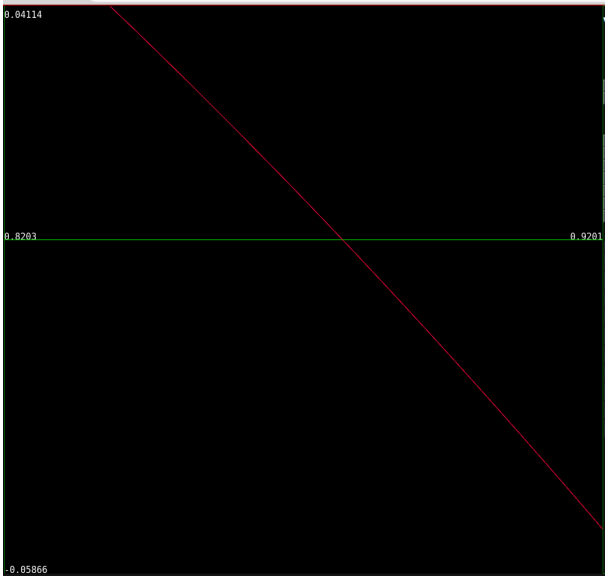


For example to solve

$\sin(x)-x^2 = 0$

we can plot sin(x)-x*x:

This obviously has one root at x =0. What is the other one? We zoom in:



For a high magnification the function looks like a straight line – which all continuous functions will.

Putting the cursor where the line crosses the x axis, we have x = 0.8768.

Checking with a calculator, sin(x) is

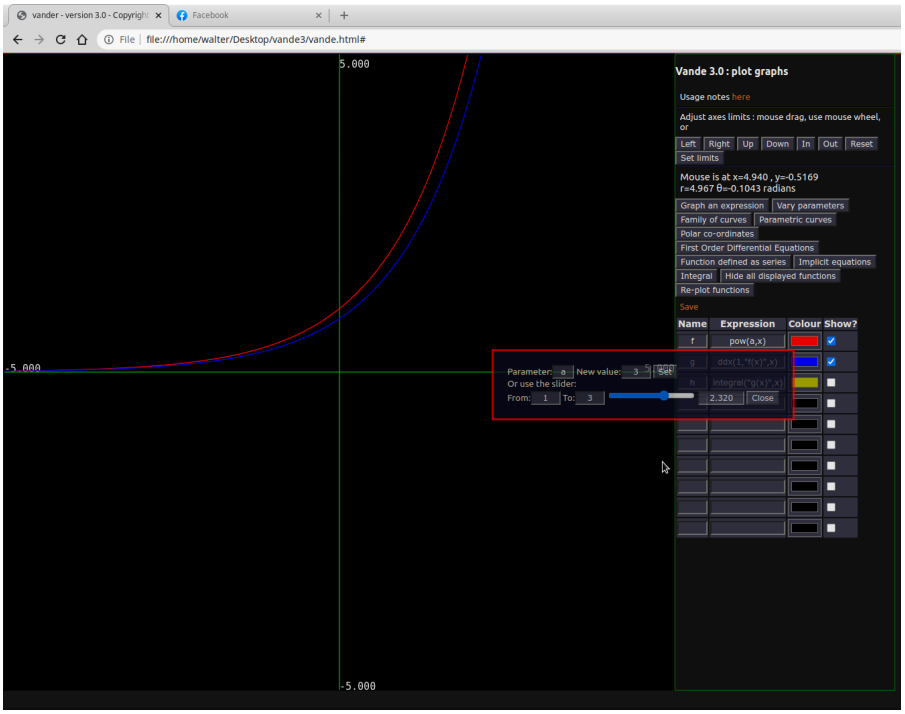
.7687

and x^2 is

.7688

so this is fairly accurate. We cannot get an exact value by this method, but it is simple and quick.

Value of e



Set up in the function list

f	pow(a,x)
g	ddx(1,"f(x)",x)

In other words

f is a^x and g is the differential of f.

When a = e, f and g are the same.

Click on 'Vary parameters' to change the value of a, from around 1 to 3. Something like this:

See that there is a value of a, somewhere around 2.7, where a^x and its differential are the same, since

$d/dx(e^x) = e^x$

Fundamental Theorem of Calculus

Suppose we set up in the function list:

f	x+5
g	ddx(1,"f(x)",x)
h	integral("g(x)",x)

In other words g is the differential of f, and h is the integral of g.

We see h is plotted over f.

In a sense this is a fix. The integral function introduces a constant of integration such that it is zero at x = xMin, the left-hand graph edge. So we have chosen f here to be a function which is zero a xMin.

But apart from that constant of integration, h and f will be the same.

The Firefox fix

Firefox has a bug which means it cannot understand the standard html <dialog> element out of the box. This describes how to fix it:

In the address bar type in

about:config

Read the warnings about degrading performance. Take care.

Scroll down to

dom.dialog_element.enabled

and click on the right to set this to true. That’s it.