Workshop on

Computer Algebra System (CAS)

Session: Graphics with CAS

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Graphics with CAS

Interpretation is the final goal of scientific work, and visualization is the most important tool.

Visualization in modern scientific study is more widely used in the development of a underlying model of a experimental or physical system.

Commercial CAS systems such as Maple^{TM} or Mathematica^{TM} provide a comprehensive visualization tool with an intuitive GUI. Maxima on the other hand links to GNUplot, a complete plotting tool but with limited GUI.

Here we learn the basics of data and problem visualization with CAS Maxima.

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The plot2d function

plot2d()

The `plot2d` is perhaps the most useful function for plotting in **Maxima** . It come in the following different forms:

```
plot2d(plot,xrange,options)
plot2d([plot 1, ..., plot n], options)
plot2d([plot 1, ..., plot n], xrange,options)
```

where, `plot`, `plot 1,...,` `plot_n` can be expressions, function names, or a list with the any of these forms:

`[[x1, ..., xn], [y1, ..., yn]],`
`[discrete, [[x1, y1], ..., [x_n, y_n]]]`, or
`[parameteric, x_expr, y-expr, t_range]`

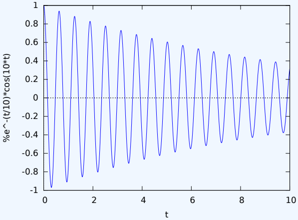
The syntax for *x* range is: `[variable, min, max]`.

The plot2d function

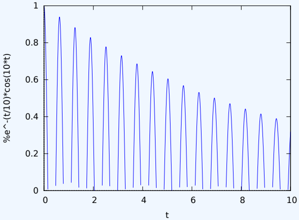
plot2d() Examples

Let us start simple by plotting the function:
$\exp(-t/10) * \cos(10 * t)$.

The default plot for t = 0 to 10



Plot with **option**: [y, 0, 1]



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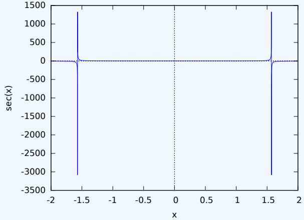
The plot2d function

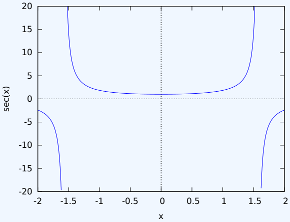
plot2d() When y-range is important

The function that goes to infinite, e.g., sec(x).

Plot of sec(x) for x = -2 to 2



Plot with **option**: [y, -20, 20]



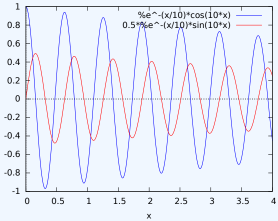
Fixing the range of y provides information when the function sec(x) will have a finite value.

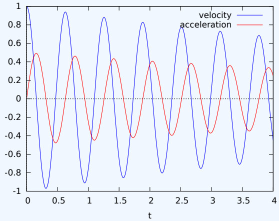
plot2d() Plotting different data

We normally plot 2 or more data in the same plot, and this necessitates the use of **legend**

we plot:
$f(t) := \exp(-t/10) * \cos(10 * t)$ and $g(t) := 0.5 * \exp(-t/10) * \sin(10 * t)$

The legend of the above plot look awful. We replace it with our own.





Similarly we can change the **labels** of *x*-axis and *y*-axis using `[xlabel," " ]` and `[ylabel," " ]`.

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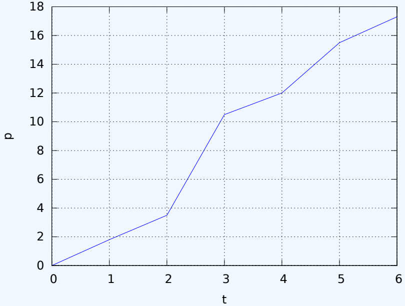
The plot2d function

plot2d() Discrete Data Plots

Say we have experimental data set pressure (p) changing over time (t), i.e., `t = [0,1,2,3,4,5,6]` and
`p = [0,1.8,3.5,10.5,12.0,15.5,17.3]`
These data can be plotted using `plot2d([discrete, t, p])`.



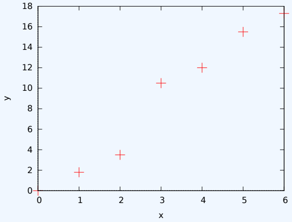
We also including the `gri2d` option in the above plot.

The plot2d function

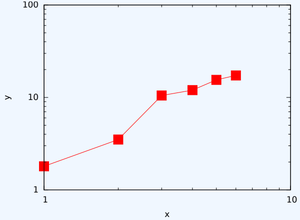
plot2d() Plot Options

The plot can be customized by many more options. Some of the other ones that we have not used are: `[xlabel, ylabel, legend, color, style, point_type, nticks, logx, logy, axes, box, plot_realpart]`.

The use of `style= [style, points]` and `point_type = [point_type, plus]`

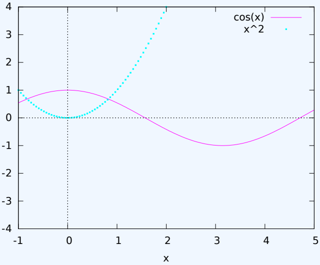


The use of `style= [style, linespoints]` and `point_type = [point_type, box]`



plot2d() Plot Options

The plot can be customized in numerous ways and there exist several commands to do that. For more options you should look at here. One more plot:



The command:

```
wxplot2d([cos(x),x^2],[x,-1,5],[y,-4,4],
[style,[lines,1,4],[points,0.3,6]]);
```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Revisiting the Open Channel Problem

Engineering calculation follows analysis. Graphics are used for Engineering Analysis.

We revisit the open channel problem once again to find out how graphics can be useful for Engineering Analysis.

The specific energy in an open channel is defined as the energy per unit weight is

$$E = \frac{v^2}{2g} + y$$

where E = specific energy, v = flow velocity, g = acceleration of gravity, and y = flow depth

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Revisiting the Open Channel Problem

The flow velocity, in turn, is defined in terms of the unit discharge (or discharge per unit width), q, as $v = q/y$, and replaced into the energy equation as:

$$E = y + \frac{q^2}{2gy^2}$$

when we substitute $q = 5$ m^2/s and g=10 m^2/s into E, we get

$$E = y + \frac{1.25}{y^2}$$

We may re-write the final expression as:

$$E(y) = y + \frac{1.25}{y^2}$$

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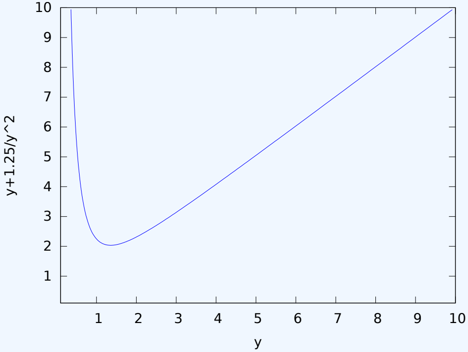
Revisiting the Open Channel Problem

$E(y)$ is now defined and can be evaluated for different values of y. A plot becomes useful here. We use

```
plot2d(E(y),[y,0.1,10],[y,0.1,10],[style,[lines,2,2]])
```



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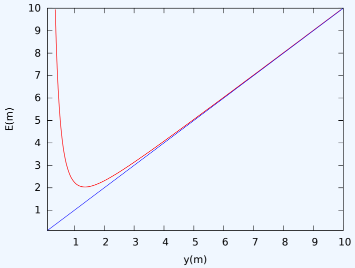
Revisiting the Open Channel Problem

Finally, we see how our energy line deviates from the equilibrium line by ploting a $y - y$ line.

```
plot2d([E(y),y],[y,0.1,10],[y,0.1,10],[style,[lines,2,2], [lines,1,1]],
[xlabel,"y(m)"],[ylabel,"E(m)"], [legend, false]
```

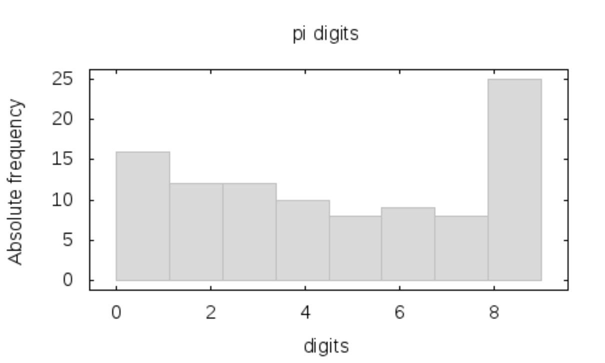


The plot show that $y > 3m$ the Energy will be inaccordance with the equilibrium line. But $y < 3m$, E explodes to infinity.

Statistical Plot

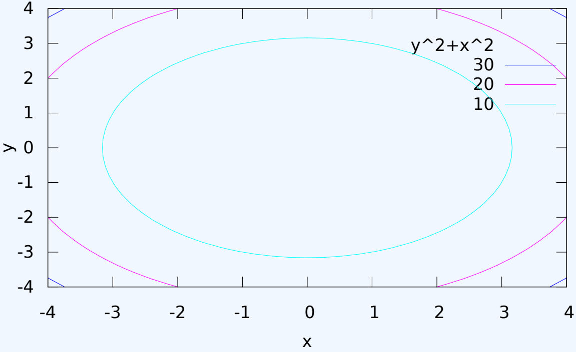
We now briefly learn about special and advanced graphics that are possible from **Maxima** .

. The Histogram from **Maxima** .



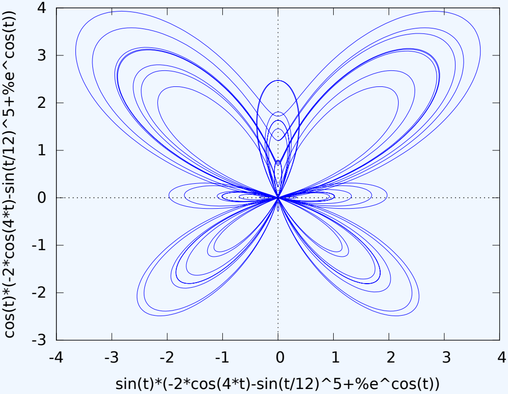
Contour Plot

The contour plot from **Maxima** .



The Butterfly

Get that butterfly curve- parametric curve



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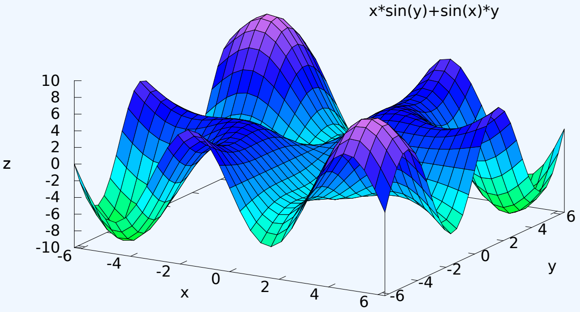
The 3D plot

The 3D plot



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The Final Thoughts

The helpful links

We explored a bit about of graphics possibilities with **Maxima** . I am listing few references that you can use to advance yourself.

1. Maxima manual can be very helpful. Get it from here.
2. A well documented graphics manual can be found at here.
3. Soon you will realize that **Maxima** contains several additional packages that can be loaded to increase its graphics output. One good documentation can be obtained from here
4. Last but not the least, the web-based **Maxima** can be used from here and the online **Maxima** manual pointing to the graphics functions is at here.

Enjoy the **Maxima** , maths and Good luck with your future works.

Contact Mr. Ruban Sugumar if you need more of Maxima

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