LabVIEW MathScript

Hans-Petter Halvorsen

Contents

LabVIEW MathScript

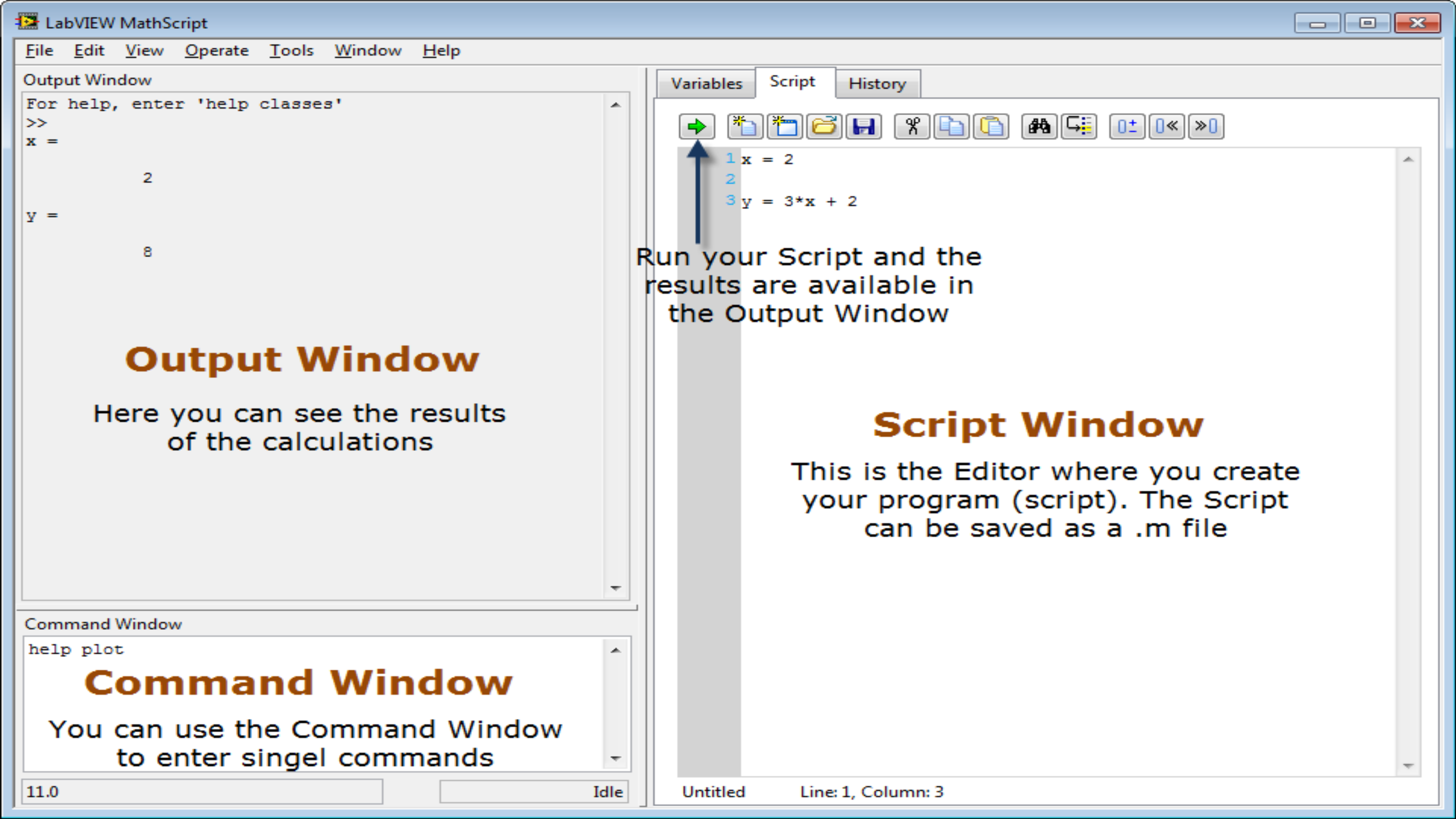
- You need to install an additional module called LabVIEW MathScript Module.
- You should also install LabVIEW Control Design and Simulation Module because it adds Control and Simulation features to the MathScript Module
- This module can be used in 2 different ways:
  - LabVIEW MathScript – A separate Application similar to MATLAB (But you need to have LabVIEW installed)
  - MathScript Node integrated in LabVIEW Code

LabVIEW MathScript Module

- Add-on Module for LabVIEW where we can do text-based programming and simulations
- GUI and syntax are identical with MATLAB
- You can run MATLAB scripts in LabVIEW MathScript with almost no changed needed (assuming you use the core functionality or the MATLAB Control Toolbox)
- LabVIEW MathScript don’t have the same speed, flexibility and toolboxes as MATLAB
- If you know MATLAB, you know LabVIEW MathScript

How do you start using MathScript?

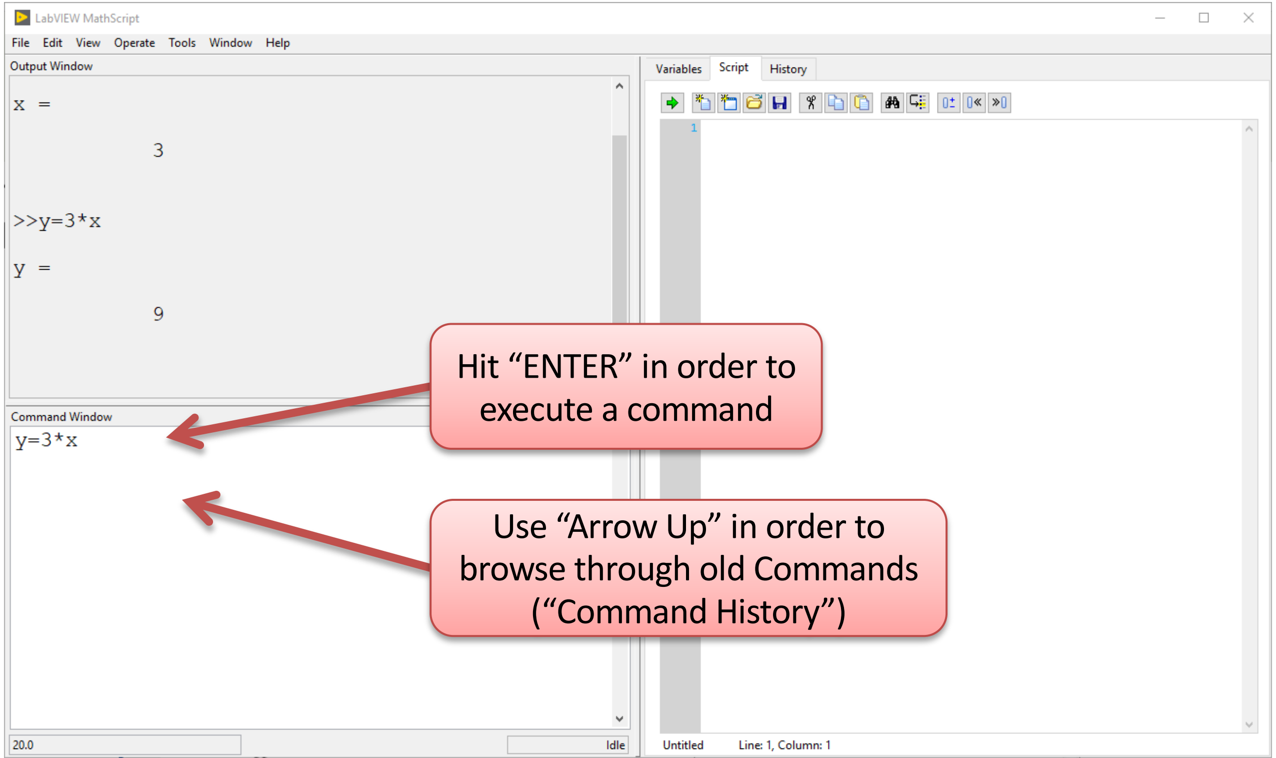
- You need to install LabVIEW and the LabVIEW MathScript Module.
- When necessary software is installed, start MathScript by open LabVIEW
- From the LabVIEW menu, select Tools -> MathScript Window...


LabVIEW MathScript
File Edit View Operate Tools Window Help
Output Window
For help, enter 'help classes'
>>
x =
2
y =
8
Output Window
Here you can see the results of the calculations
Command Window
help plot
Command Window
You can use the Command Window to enter singel commands
11.0
Idle
Variables
Script
History
x = 2
y = 3*x + 2
Run your Script and the results are available in the Output Window
Script Window
This is the Editor where you create your program (script). The Script can be saved as a .m file
Untitled
Line: 1, Column: 3

Basic Examples

Command Window

The Command Window is the main window in MathScript. Use the Command Window to enter variables and to run functions and M-files scripts (more about m-files later). Its like an advanced calculator!



Case Sensitive Variables

MathScript/MATLAB is **case sensitive**! The variables *x* and *X* are not the same.

```
>> x=5;
>> X=6;
>> x+X

ans =
     11
```

```
>> x=3
x =
     3

>> y=4;
>>
```

Unlike many other languages, where the semicolon is used to terminate commands, in MathScript/MATLAB the semicolon serves to suppress the output of the line that it concludes.

clear/clc

```
>> clear
>> clc
```

The "clear" command deletes all existing variables" from the memory

The "clc" command removes everything from the Command Window
clc – clear command window

Built-in Constants

Name	Description
i, j	Used for complex numbers, e.g., z=2+4i
pi	π
inf	∞, Infinity
NaN	Not A Number. If you, e.g., divide by zero, you get NaN

```
>> r=5;
>> A=pi*r^2

A =
    78.5398
```

```
>> z1=3+3i;
>> z2=3+5i;
>> z = z1+z2
z =
   6.0000 + 8.0000i
```

```
>> a=2;
>> b=0;
>> a/b
```

Mathematical Expressions

$$y(x) = \frac{3x + 2}{2}$$

$$y(2) = ?$$

```
>> x=2;
>> y=3*x+2/2
y =
     7
>> y=(3*x+2)/2
y =
     4
```

Which are correct?

	MATLAB
$\ln(x)$	log(x)
$\log_{10}(x)$	log10(x)
$\sqrt{x}$	sqrt(x)
e^x	exp(x)
x^2	x^2

Calculate this expression, try with different values for x and y

$$z = 3x^2 + \sqrt{x^2 + y^2} + e^{\ln(x)}$$

Mathematical Expressions

$$z = 3x^2 + \sqrt{x^2 + y^2} + e^{\ln(x)}$$

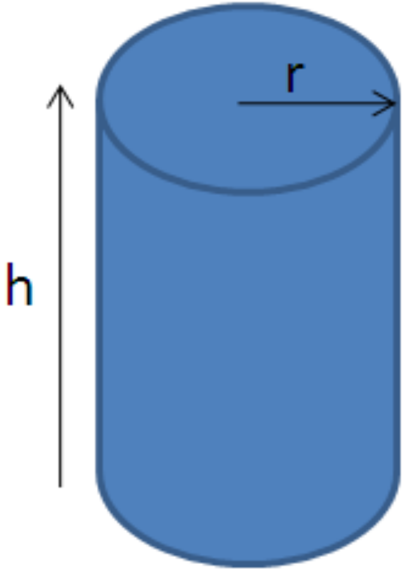
```
>> x=2;, y=2
>> z = 3*x^2 + sqrt(x^2 + y^2) + exp(log(x))

ans =
   16.8284
...
```

Solving Mathematical Problems

We will use MathScript in order to find the surface area of a cylinder based on the height (h) and the radius (r) of the cylinder

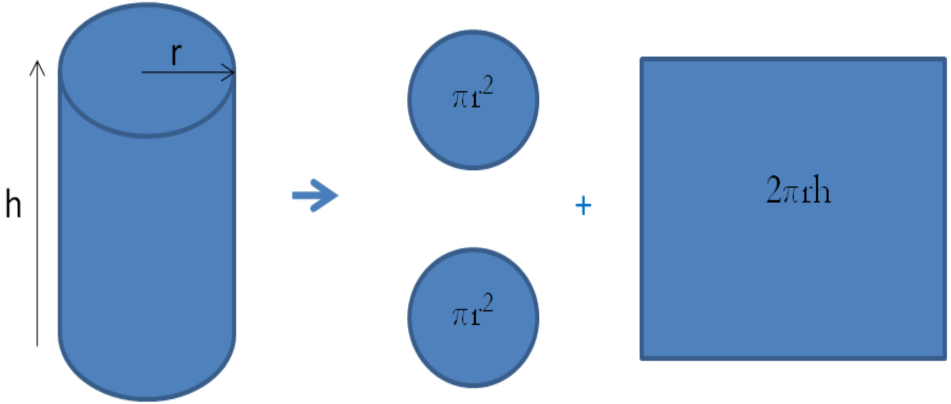
$$r = 3$$

$$h = 8$$



$$A = ?$$

Solving Mathematical Problems



MathScript Code:

```
>> h=8
>> r=3
>> A = 2*pi*r^2 +2*pi*r*h;
A =
  207.3451
```

Plotting

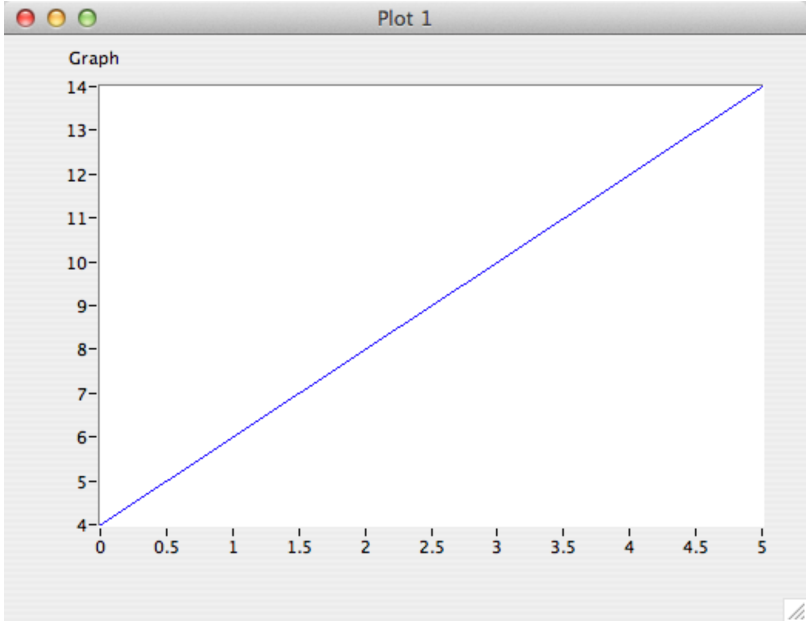
Plotting

Example:

$$y(t) = 2x + 4$$

interval on x axis

```
x = 0:5;

y = 2*x  + 4;

plot(x,y)
```



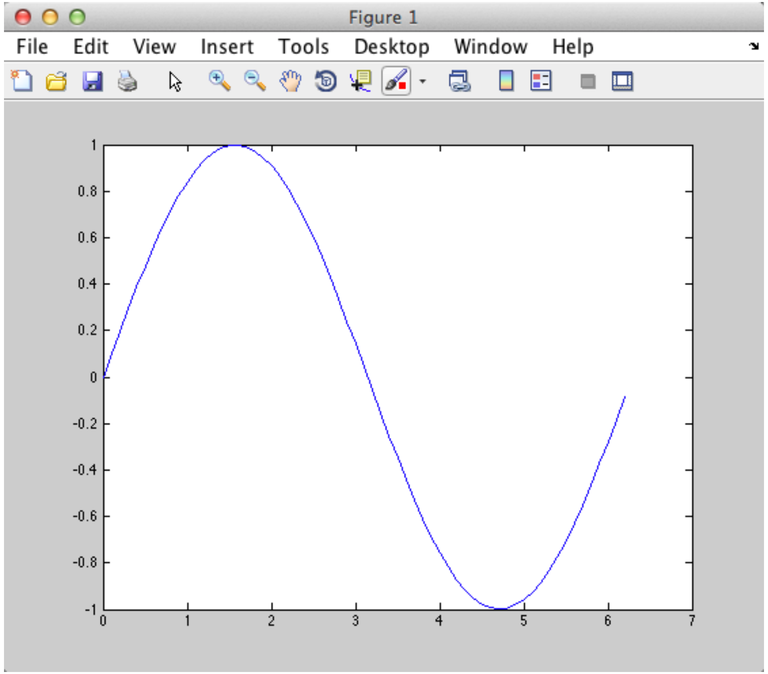
Useful MathScript functions for plotting: plot(), xlabel(), ylabel(), title(), grid()

Some Examples

```
>> x = 0:0.1:2*pi;
>> y = sin(x);
>> plot(x,y)
```

```
>> x = 0:0.1:2*pi;
>> y = sin(x);
>> y2 = cos(x);
>> plot(x,y, x,y2)
```

```
...
>> plot(x,y,'r*', x,y2,'g+')
```



Plotting Functions

Plotting functions:

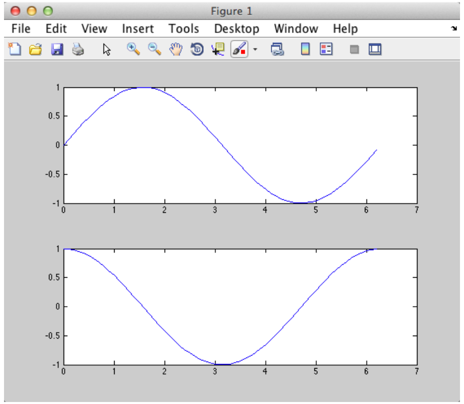
Name	Description
plot	Create a Plot
figure	Define a new Figure/Plot window
grid on/off	Create Grid lines in a plot
title	Add Title to current plot
xlabel	Add a Label on the x-axis
ylabel	Add a Label on the x-axis
axis	Set xmin,xmax,ymin,ymax
hold on/off	Add several plots in the same Figure
legend	Create a legend in the corner (or at a specified position) of the plot
subplot	Divide a Figure into several Subplots

Examples:

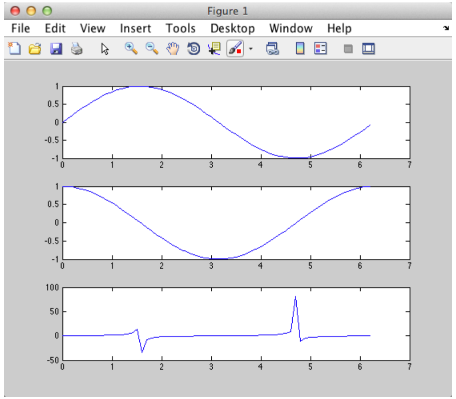
```
>> x=0:0.1:2*pi;
>> y=sin(x);
>> plot(x,y)
>> title('Plot Example')
>> xlabel('x')
>> ylabel('y=sin(x)')
>> grid on
>> axis([0,2*pi,-1,1])
>> legend('Temperature')
```

Subplots

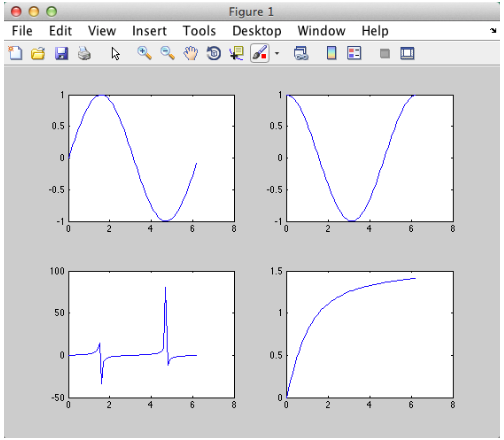
```
>> x=0:0.1:2*pi;
>> y=sin(x);
>> y2=cos(x);

>> subplot(2,1,1)
>> plot(x,y)

>> subplot(2,1,2)
>> plot(x,y2)
```




```
>> x=0:0.1:2*pi;
>> y=sin(x);
>> y2=cos(x);
>> y3=tan(x);

>> subplot(3,1,1)
>> plot(x,y)

>> subplot(3,1,2)
>> plot(x,y2)

>> subplot(3,1,3)
>> plot(x,y3)
```




```
>> x=0:0.1:2*pi;
>> y=sin(x);
>> y2=cos(x);
>> y3=tan(x);
>> y4=atan(x);

>> subplot(2,2,1)
>> plot(x,y)

>> subplot(2,2,2)
>> plot(x,y2)

>> subplot(2,2,3)
>> plot(x,y3)

>> subplot(2,2,4)
>> plot(x,y4)
```



Simulation Example

Simulation Example

Assume the following model (Differential Equation):

$$\dot{x} = -ax + bu$$

We start by setting $a = 0.25$ and $b = 2$

Then we get:

$$\frac{x(k+1) - x(k)}{T_s} = -ax(k) + bu(k)$$

Finally, we get:

$$x(k+1) = (1 - T_s a)x(k) + T_s bu(k)$$

This is the discrete version of the differential equation

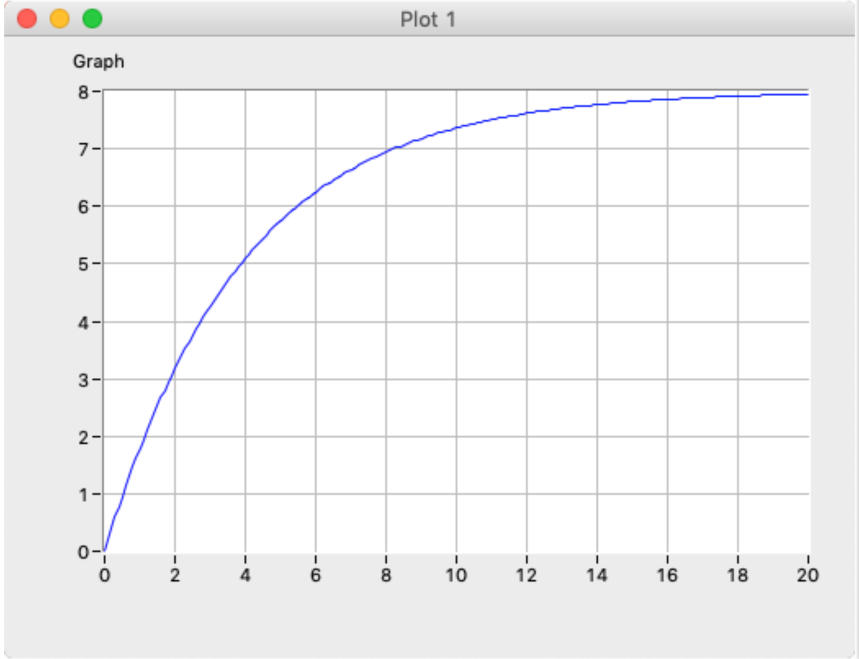
In order to simulate this system in LabVIEW MathScript we typically need to find the <u>discrete</u> differential equation.

We can use e.g., the **Euler Approximation**:

$$\dot{x} \approx \frac{x(k+1) - x(k)}{T_s}$$

Where T_s is the Sampling Time

Code




```
% Simulation of discrete model
clear, clc

% Model Parameters
a = 0.25;b = 2;

% Simulation Parameters
Ts = 0.1; %s
Tstop = 20; %s
uk = 1; % Step Response
x(1) = 0;

% Simulation
for k=1:(Tstop/Ts)
        x(k+1) = (1-a*Ts).*x(k) + Ts*b*uk;
end

% Plot the Simulation Results
k=0:Ts:Tstop;
plot(k,x)
grid on
```

Creating Functions

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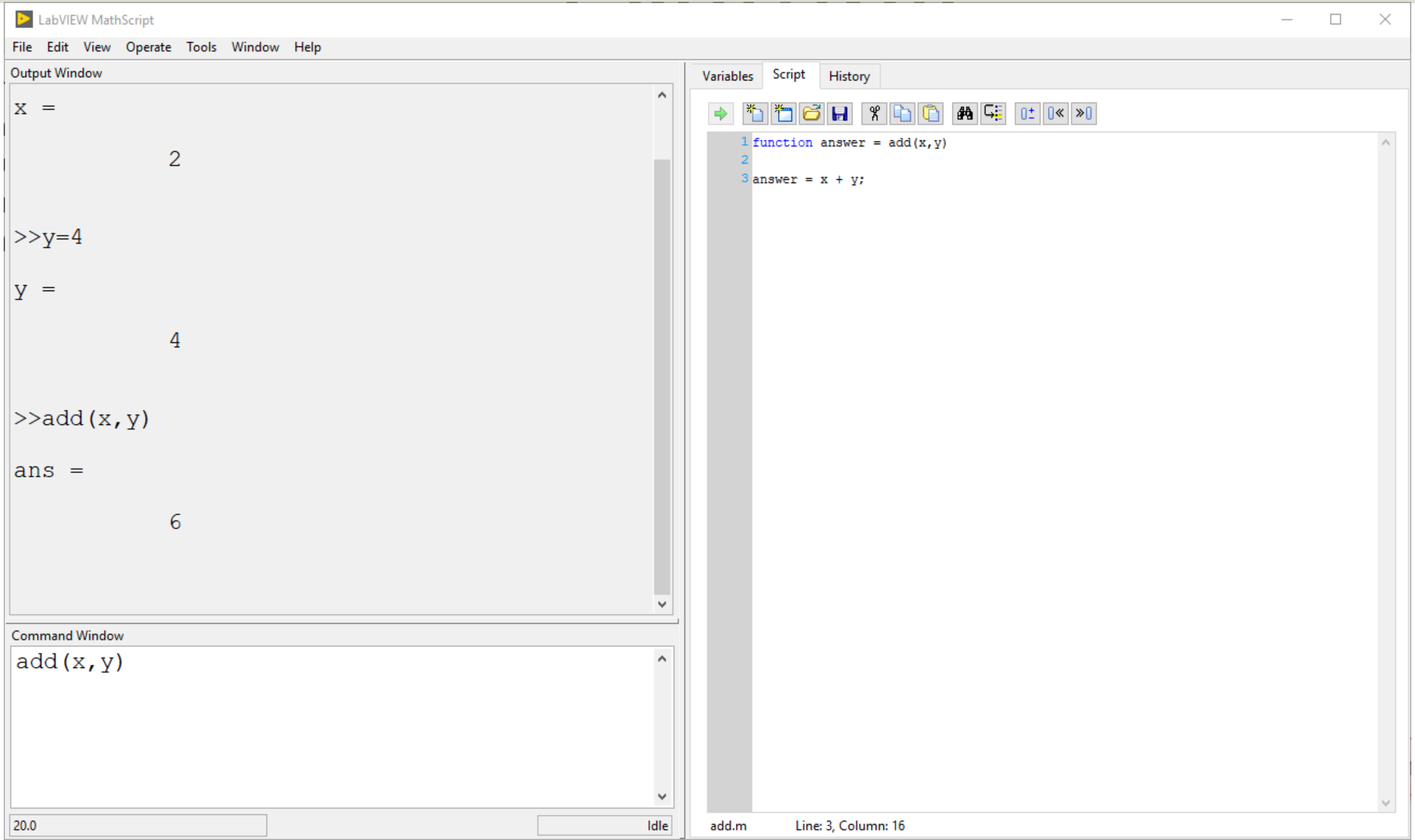
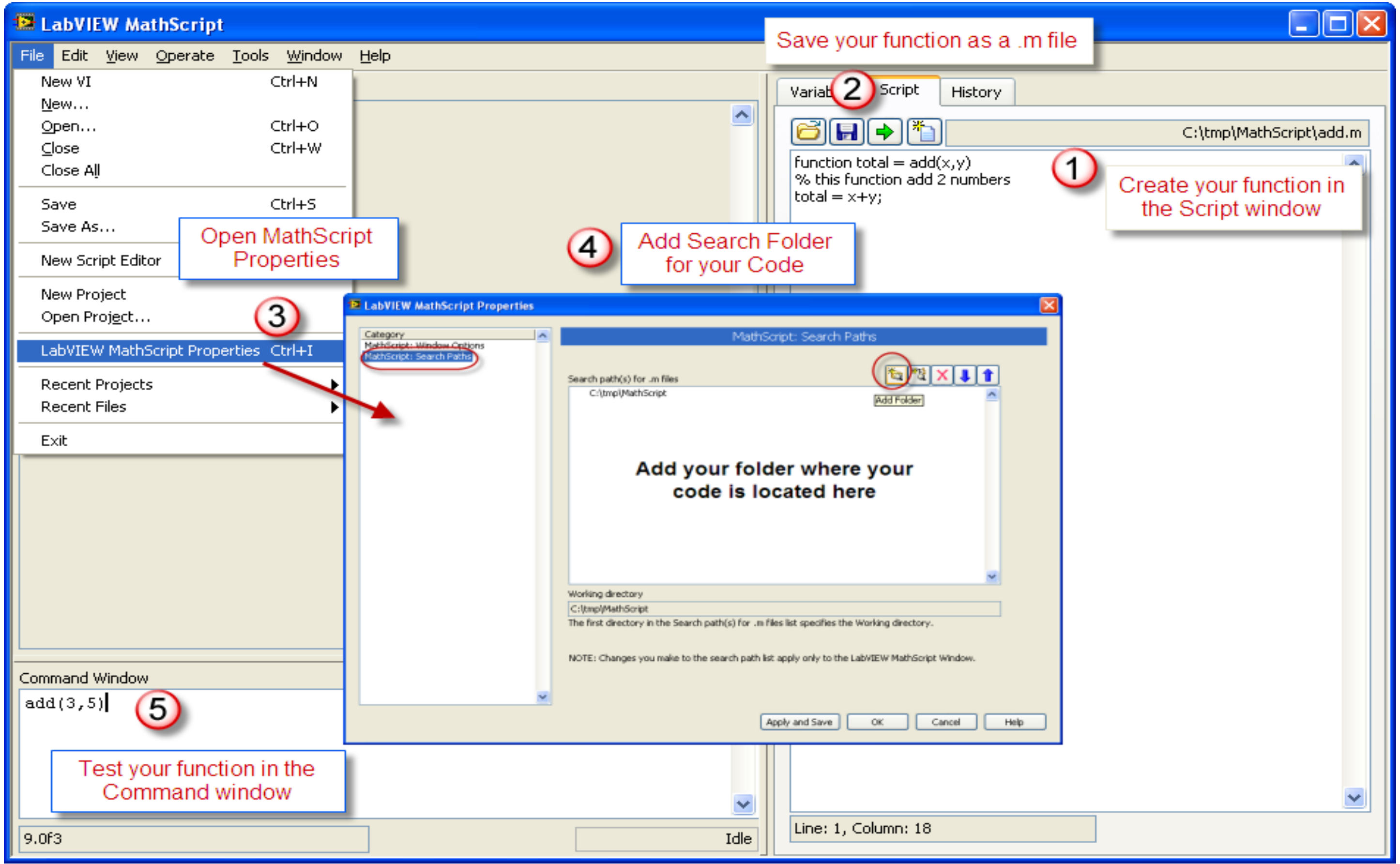
Create Function



Create Functions in MathScript



Celsius to Fahrenheit

$$T_F = \frac{9}{5}T_C + 32$$

Step 1: Create the Function

Function name

Return value

input

```
function Tf = fahrenheit(Tc)

Tf = (9/5)*Tc + 32;
```

Return value

The function body

The function needs to be saved as "**fahrenheit.m**" on your hard drive

Step 2: Execute the Function

```
Tc = 23;
Tf = fahrenheit(Tc)
```

This can be done from Command window or Script window

Tips and Tricks

Tips and Tricks

Use Comments (%)

```
% This is a comment
x=2; % Comment2
y=3*x % Comment3
```

- but that have to make sense!

DO NOT use ”spaces” in Filename or names that are similiar to built-in functions in MathScript/MATLAB!

Decimal sign: Use ”.”– NOT ”,” !
i.e. *y=3.2* – not *y=3,2*

Use english names on variables, functions, files, etc. This is common practice in programming!
Use always variables – Do not use numbers directly in the expressions!

Yes:

```
a=2;
b=4;
y=a+
b
```

No:

```
y=2+
4
```

Functions:

- Only ONE function in each File!
- The Filename (.m) AND the Name of the Function MUST be the same!

```
clear
clc
close all
…
```

Always include these lines in your Script

Tips and Tricks

Use help in order to find out how to use a function in MathScript/MATLAB. In order to get help for the tf function, type the following in the Command window:

```
help tf
```

Greek letters: In math and control theory it is common to use Greek letters in formulas, etc. These cannot be used directly in MathScript/MATLAB, so you need to find other good alternatives.

Examples:

ω_0 – w0

ζ – zeta or just z

etc.

A Golden Rule: One Task – one file, i.e. DONT put all the Tasks in one single file!!

Mathematical expressions:
The following applies in MathScript/MATLAB

x^2	`x^2`
$\sqrt{x}$	`sqrt(x)`
$ln(x)$	`log(x)`
$\log(x)$	`log10(x)`
e^x	`exp(x)`
π	`pi`

$$z = 3x^2 + \sqrt{x^2 + y^2} + e^{\ln(x)}$$

$$z(2,2) = ?$$

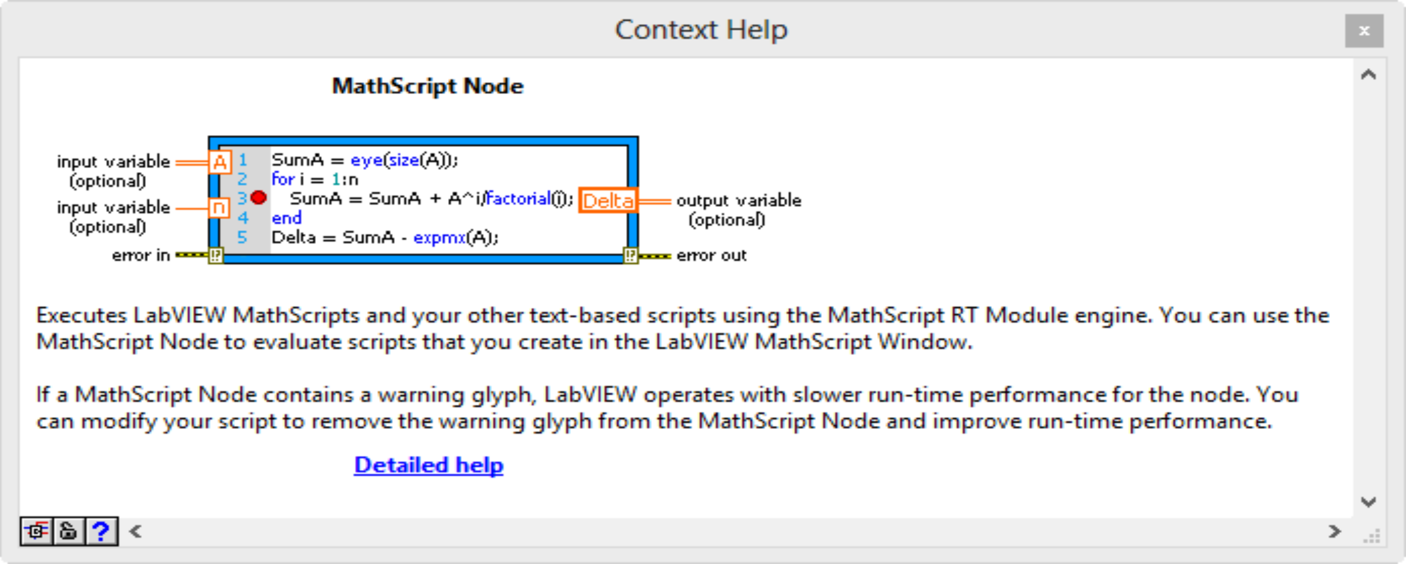
```
x = 2;
y = 2;
z = 3*x^2 + sqrt(x^2 + y^2)+ exp(log(x))
```

MathScript Node

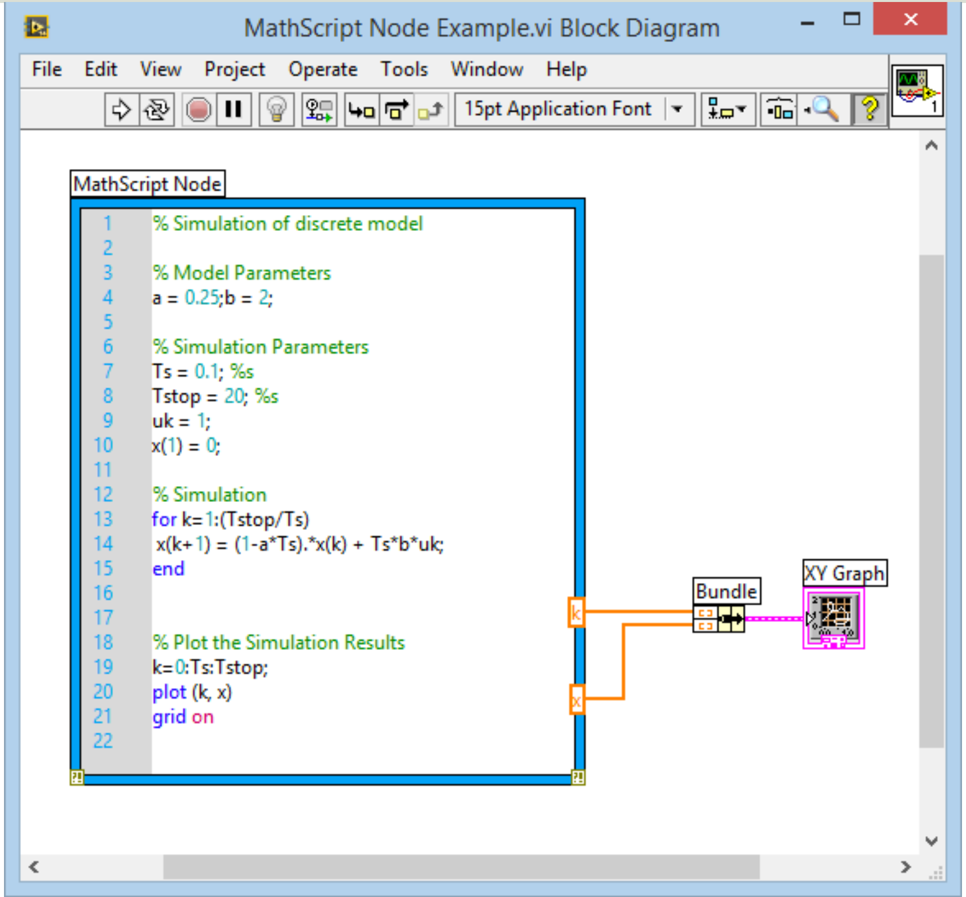
Hans-Petter Halvorsen

MathScript Node

With MathScript Node you can create and use MathScript/MATLAB code within LabVIEW



Example

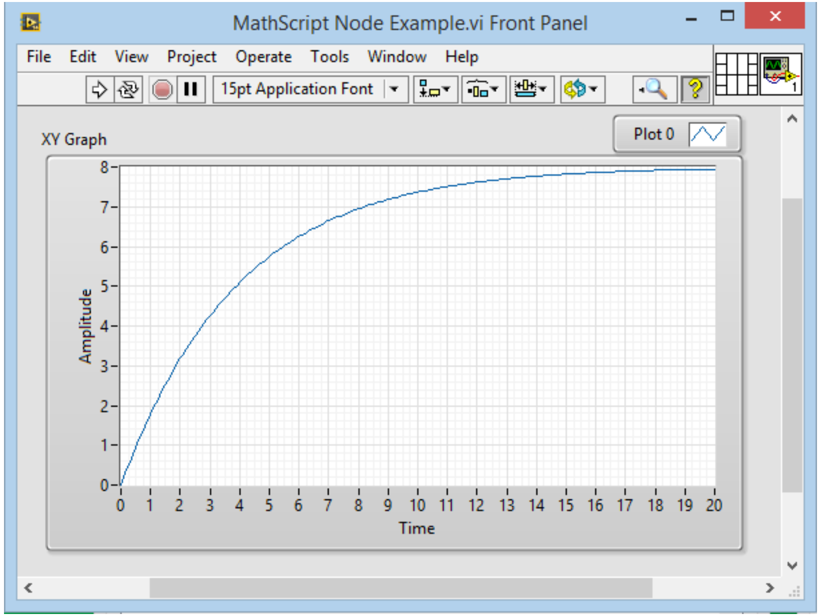

MathScript Node Example.vi Block Diagram
File Edit View Project Operate Tools Window Help
15pt Application Font
MathScript Node
% Simulation of discrete model

% Model Parameters
a = 0.25;b = 2;

% Simulation Parameters
Ts = 0.1; %s
Tstop = 20; %s
uk = 1;
x(1) = 0;

% Simulation
for k=1:(Tstop/Ts)
x(k+1) = (1-a*Ts).*x(k) + Ts*b*uk;
end

% Plot the Simulation Results
k=0:Ts:Tstop;
plot (k, x)
grid on
k
x
Bundle
XY Graph


MathScript Node Example.vi Front Panel
File Edit View Project Operate Tools Window Help
15pt Application Font
XY Graph
Plot 0
Amplitude
0 1 2 3 4 5 6 7 8
Time
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

Alternative: Formula Node

MathScript Node

```
% Simulation of discrete model

% Model Parameters
a = 0.25;b = 2;

% Simulation Parameters
Ts = 0.1; %s
Tstop = 20; %s
uk = 1; % Step Response
x(1) = 0;

% Simulation
for k=1:(Tstop/Ts)
 x(k+1) = (1-a*Ts).*x(k) + Ts*b*uk;
end

% Plot the Simulation Results
t=0:Ts:Tstop;
plot(t,x)
grid on
```

t, x → Bundle → XY Graph

The MathScript Node uses MATLAB syntax

The Formula Node uses C syntax

Formula Node

```
//Model Parameters
float a = 0.25;
float b = 2;

//Simulation Parameters
float Ts = 0.1;
float Tstop = 20;
float uk = 1;
float xk = 0;
float xk1 = 0;
int k;
int N = Tstop/Ts;

float t[200];
float x[200];

for (k=1; k<N; k++)
{
   xk1= (1-a*Ts) * xk + Ts*b*uk;

   xk = xk1;

   t[k] = Ts*k;
   x[k] = xk1;
}
```

t, x → Bundle → XY Graph 2

Hans-Petter Halvorsen

University of South-Eastern Norway

www.usn.no

E-mail: hans.p.halvorsen@usn.no

Web: https://www.halvorsen.blog