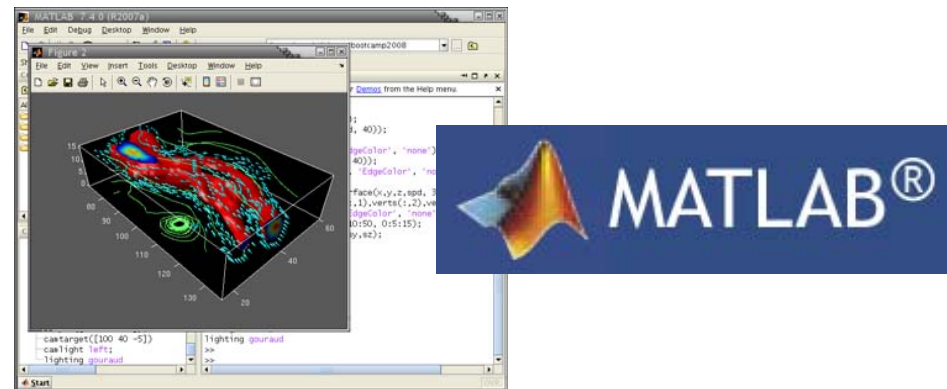


# Introduction to Scientific Programming in MATLAB



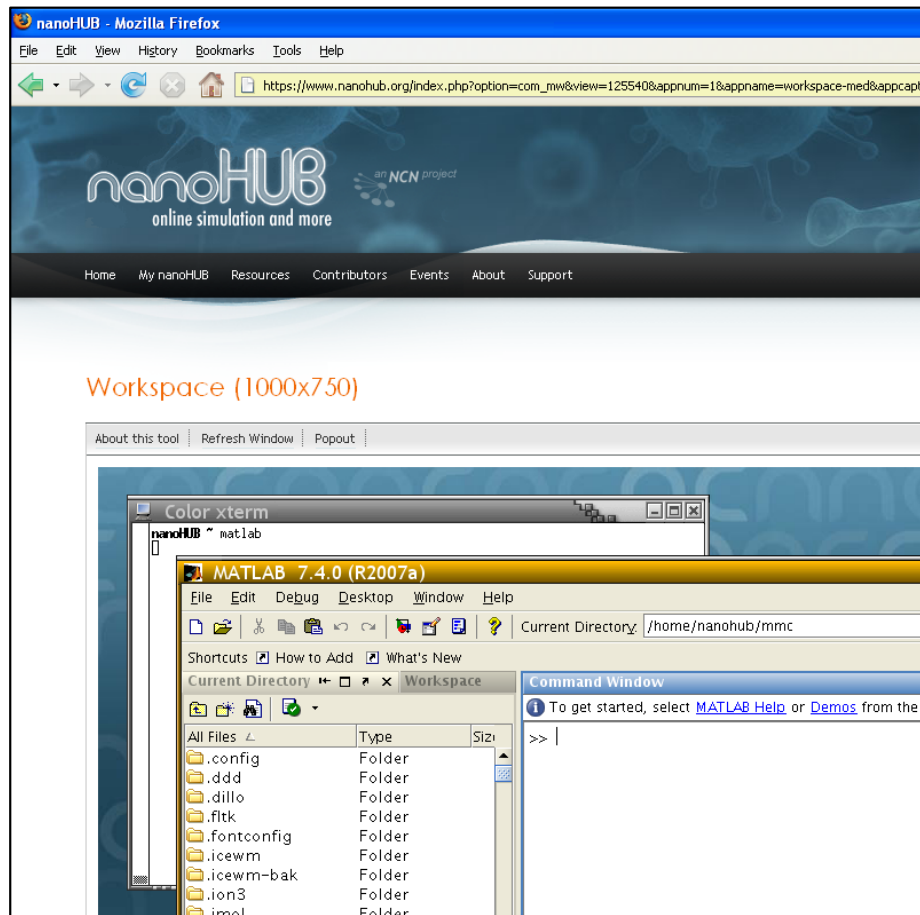
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Software Architect

HUBzero™ Platform for Scientific Collaboration

# Accessing MATLAB

Start a workspace and type `matlab`



**NOTE: MATLAB requires a license from Purdue, so this works only when accessing from Purdue's campus.**

Try some simple commands:

```
>> x=1
```

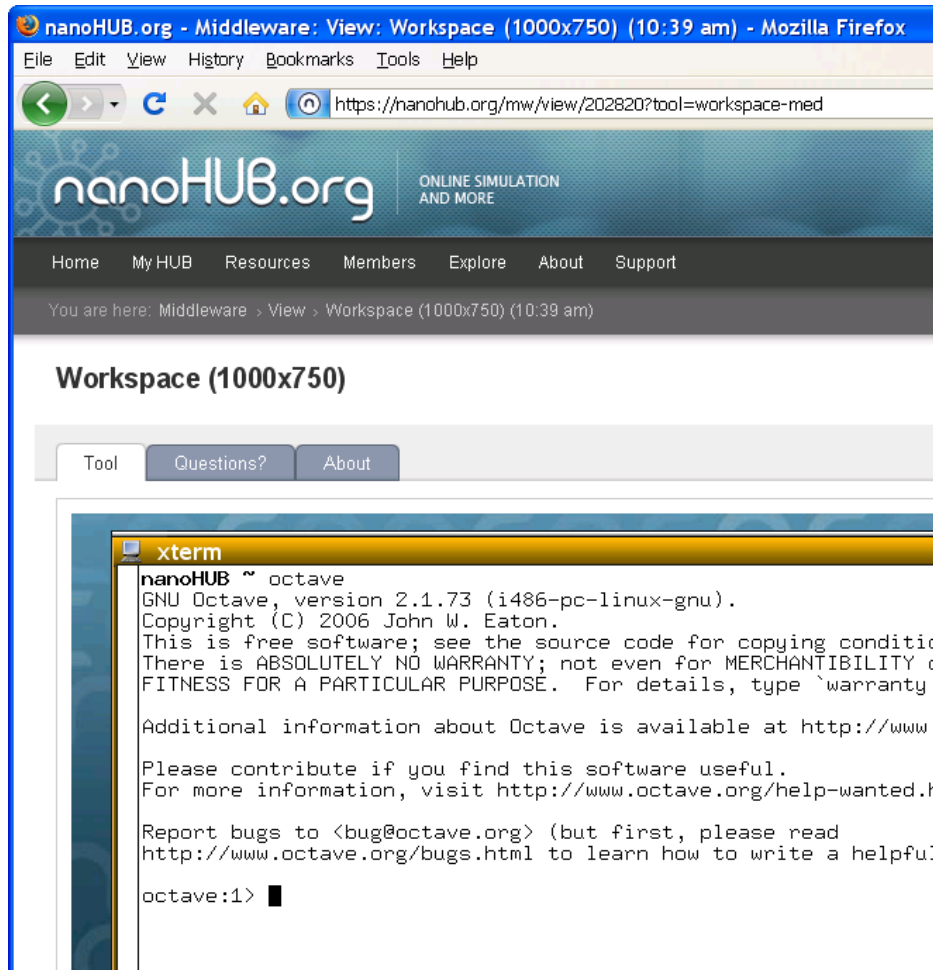
```
>> y=2
```

```
>> z=2*x + y
```

```
>> exit
```

# Free Clone: GNU Octave

In your workspace, type octave



The screenshot shows a web browser window titled "nanoHUB.org - Middleware: View: Workspace (1000x750) (10:39 am) - Mozilla Firefox". The address bar shows the URL "https://nanohub.org/mw/view/202820?tool=workspace-med". The page header includes the nanoHUB.org logo and navigation links. Below the header, there is a section titled "Workspace (1000x750)" with tabs for "Tool", "Questions?", and "About". The "Tool" tab is active, displaying a terminal window titled "xterm". The terminal output shows the GNU Octave version 2.1.73 (i486-pc-linux-gnu) startup screen, including copyright information and a list of links for more information.

```
nanoHUB ~ octave
GNU Octave, version 2.1.73 (i486-pc-linux-gnu).
Copyright (C) 2006 John W. Eaton.
This is free software; see the source code for copying conditio
There is ABSOLUTELY NO WARRANTY; not even for MERCHANTABILITY o
FITNESS FOR A PARTICULAR PURPOSE. For details, type `warranty'

Additional information about Octave is available at http://www.

Please contribute if you find this software useful.
For more information, visit http://www.octave.org/help-wanted.h

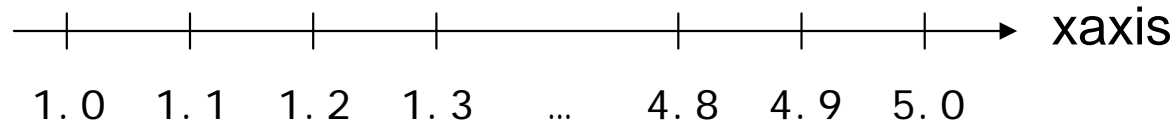
Report bugs to <bug@octave.org> (but first, please read
http://www.octave.org/bugs.html to learn how to write a helpful

octave:1> █
```

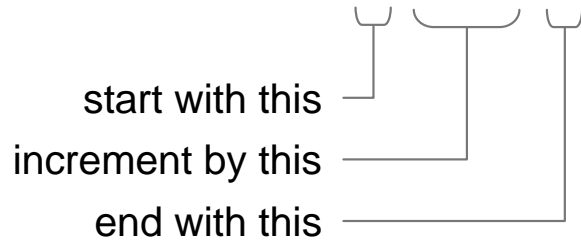
- ✓ Runs almost all MATLAB scripts
- ✓ Creates plots
- ✗ Missing fancy debugger
- ✗ Missing “simulink” toolbox

# Using Vectors

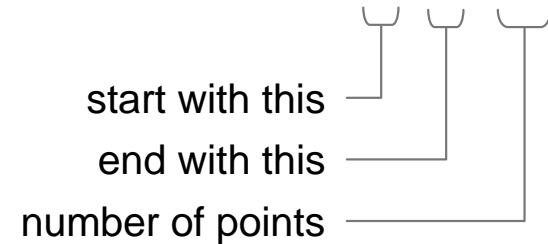
Create a series of number like this:



`xaxis = 1:0.1:5`



`xaxis = linspace(1, 5, 41)`



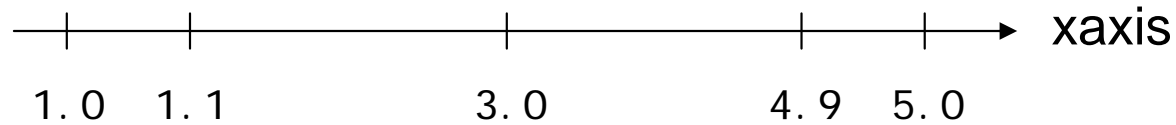
Try this:

```
>> xaxis = 1:0.1:5;
>> length(xaxis)
>> xaxis
```

Try it with/without the semicolon.  
What does the semicolon do?

# More Vectors

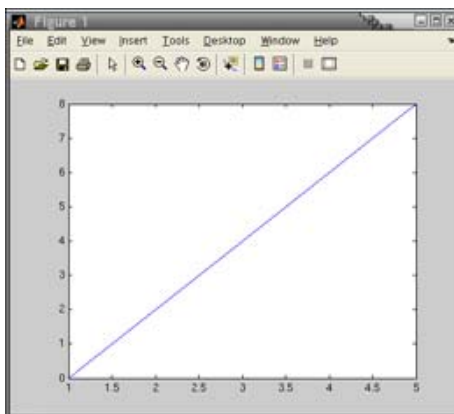
Suppose you have an irregular spacing:



`xaxis = [1.0, 1.1, 3.0, 4.9, 5.0]`

square brackets

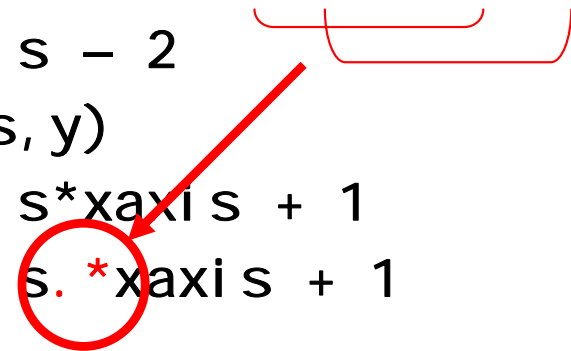
comma-separated list of values



Try this:

```
>> y = 2*xaxis - 2
>> plot(xaxis, y)
>> y = 3*xaxis*xaxis + 1
>> y = 3*xaxis.*xaxis + 1
```

Multiply element by element:  
[1.0 1.1 ...] [1.0 1.1 ...]



## Matrices

Suppose you want to define a matrix, like this:

$$a = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

in MATLAB, that's

```
>> a = [-1 -1 -1 ; 0 0 0 ; 1 1 1]
```

$$a^T = \begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$$

in MATLAB, that's

```
>> a'
```

Try this:

```
>> a * a'
```

```
>> a' * a
```

```
>> a' * a + 1
```

Try these built-in functions:

```
>> zeros(3)
```

```
>> ones(4)
```

```
>> eye(2)
```

```
>> a * a' + eye(3)
```

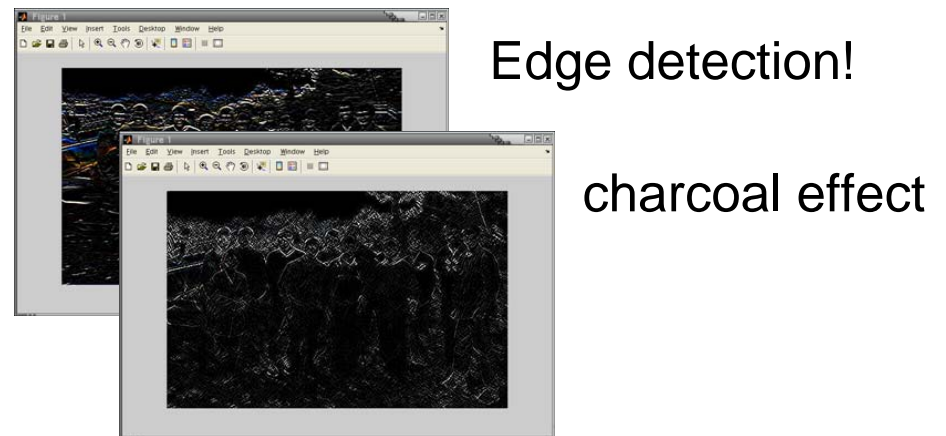
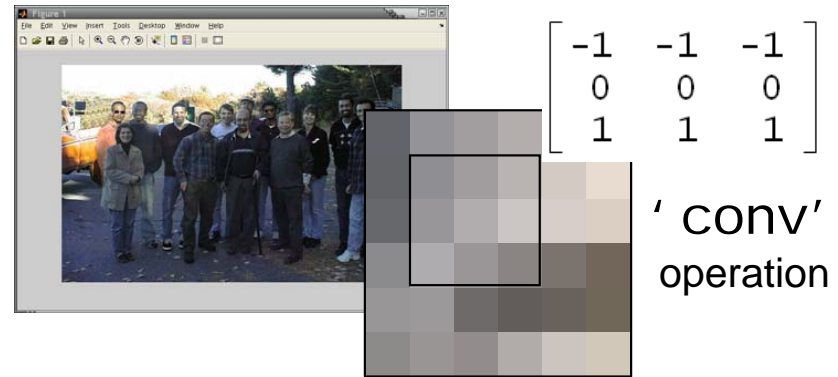
# Image Processing

Try this:

```
>> im = imread(' /apps/matlab/7.5/toolbox/simulink/simulink/team.jpg ');
>> figure;
>> imshow(im);

>> a = [-1 -1 -1 ; 0 0 0 ; 1 1 1]
>> im2 = imfilter(im, a, 'conv');
>> imshow(im2);

>> im2 = imfilter(im, a*a', 'conv');
>> imshow(im2);
```



### Octave Users:

Works in Octave 3.0

For earlier versions, download *imread* from

<http://www.cs.helsinki.fi/u/ahyvarin/kurssi/imread.m>

# Matrix Indexing

$$a = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

in MATLAB, that's

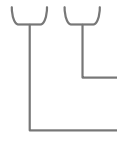
```
>> a = [-1 -1 -1 ; 0 0 0 ; 1 1 1]
```

Try this:

```
>> a(1, 1)
```

```
>> a(2, 1)
```

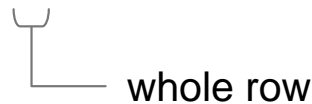
```
>> a(1, 2)
```


  
column index  
row index

Try this:

```
>> a(1, 1:3)
```

```
>> a(1, :)
```


  
whole row

Try this:

```
>> a(2, 2) = 3
```

```
>> a
```

Pick apart image pixel by pixel...

```
>> i m(1, 5)
```

```
>> i m(3, :)
```

```
>> i m(1:100, 1:100)
```

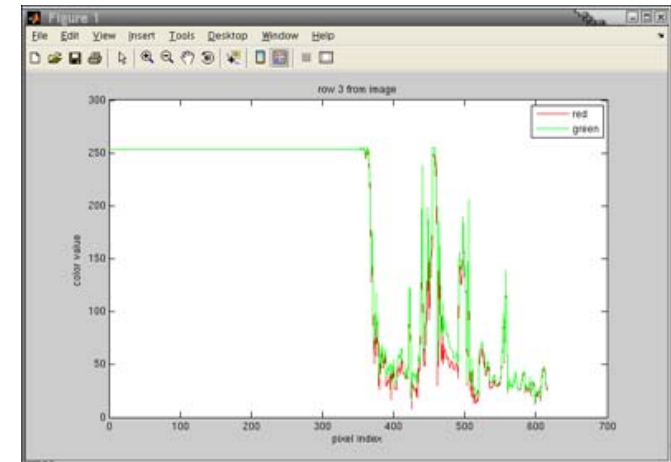
## Back to Plotting

Try this:

```
>> rv = im(3, :, 1)
```

first component: r g b  
all column elements  
row index

```
>> plot(1:length(rv), rv, 'r')  
>> title('row 3 from image')  
>> xlabel('pixel index')  
>> ylabel('color value')  
>> hold  
>> gv = im(3, :, 2)  
>> plot(1:length(gv), gv, 'g')  
>> legend('red', 'green')
```

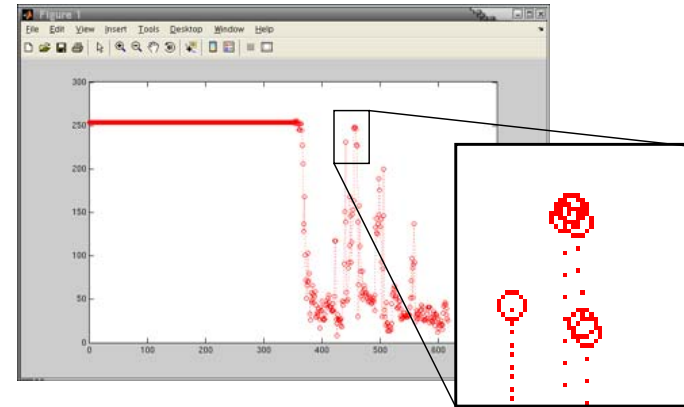


# Plotting Options

Try this:

```
>> cl f
>> plot(1:length(rv), rv, 'r:o')
```

red, dotted line, circles



|   |         |    |                      |   |                               |
|---|---------|----|----------------------|---|-------------------------------|
| r | Red     | -  | Solid line (default) | + | Plus sign                     |
| g | Green   | -- | Dashed line          | o | Circle                        |
| b | Blue    | :  | Dotted line          | * | Asterisk                      |
| c | Cyan    | -. | Dash-dot line        | . | Point                         |
| m | Magenta |    |                      | x | Cross                         |
| y | Yellow  |    |                      | s | Square                        |
| k | Black   |    |                      | d | Diamond                       |
| w | White   |    |                      | ^ | Upward-pointing triangle      |
|   |         |    |                      | v | Downward-pointing triangle    |
|   |         |    |                      | > | Right-pointing triangle       |
|   |         |    |                      | < | Left-pointing triangle        |
|   |         |    |                      | p | Five-pointed star (pentagram) |
|   |         |    |                      | h | Six-pointed star (hexagram)   |

## Functions

file: edgematrix.m

```
% returns edge detection matrix of size n
% orient is 'horz' for horizontal edges, and 'vert' for vertical
function m = edgematrix(n, orient)
    half = floor(n/2);
    n = 2*half + 1;
    for i=1:n
        for j=1:n
            if strcmp(orient, 'horz')
                m(i,j) = j-half-1;
            else
                m(i,j) = i-half-1;
            end
        end
    end
end
```

```
im2 = imfilter(im, edgematrix(5, 'horz'), 'conv');
```



# Conditionals

file: edgematrix.m

```
% returns edge detection matrix of size n
% orient is 'horz' for horizontal edges, and 'vert' for vertical
function m = edgematrix(n, orient)
    half = floor(n/2);
    n = 2*half + 1;
    for i=1:n
        for j=1:n
            if strcmp(orient, 'horz')
                m(i,j) = j-half-1;
            else
                m(i,j) = i-half-1;
            end
        end
    end
end
```

|       |  |                      |
|-------|--|----------------------|
| $m =$ | $\begin{bmatrix} -1 & 0 & 1 \\ -1 & 0 & 1 \\ -1 & 0 & 1 \end{bmatrix}$ | 'horz'               |
| $m =$ | $\begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$ | <i>anything else</i> |

# Programming the MATLAB Way

file: edgematrix.m

```
% returns edge detection matrix x of size n
% orient is 'horz' for horizontal edges, and 'vert' for vertical
function m = edgematrix(n, orient)
    half = floor(n/2);
    n = 2*half + 1;
    for i=1:n
        for j=1:n
```

```
% returns edge detection matrix x of size n
% orient is 'horz' for horizontal edges, and 'vert' for vertical
function m = edgematrix2(n, orient)
    half = floor(n/2);
    o = ones(2*half + 1);
    m = [-half:half]' * o(1,:);
    if strcmp(orient, 'horz')
        m = m';
    end
```

$$\begin{bmatrix} -1 \\ 0 \\ 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \end{bmatrix} = \begin{bmatrix} -1 & -1 & -1 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}$$

# Simple Input/Output

file: hel l o . m

```
% prompt for a phrase and say "hello"
di sp(' Who are you? ');
name = input(' Enter your name: ', 's');
age = input(' Enter your age: ');

mesg = sprintf(' Hello, %s!', name);
di sp(mesg);

fi le = input(' Enter a fi le name: ', 's');
fi d = fopen(fi le, 'w');
fpri ntf(fi d, '%s is %d years ol d\n', name, age);
fcl ose(fi d);
```

String input  
Numbers and  
other stuff

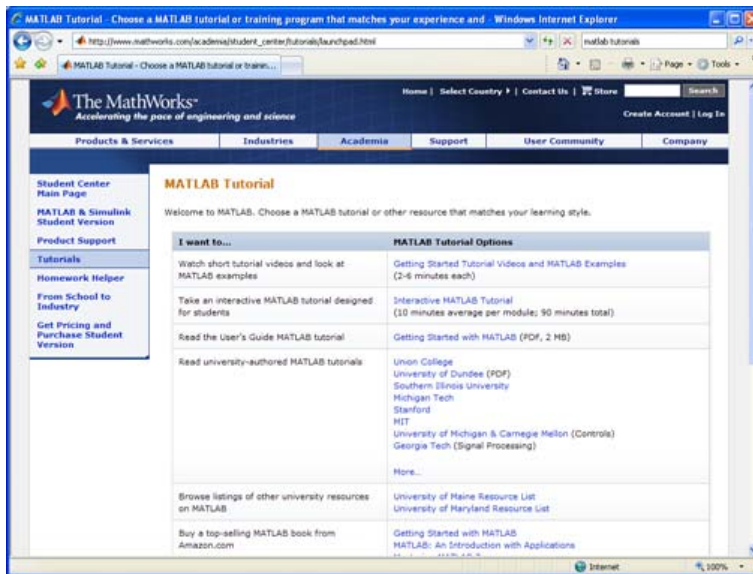
Use script name as a  
command to invoke  
the script

```
>> hel l o
Who are you?
Enter your name: Michael
Enter your age: 43
Hello, Michael!
Enter a file name: info.txt
```

# Other Resources

## Tutorials at MathWorks

[http://www.mathworks.com/academia/student\\_center/tutorials/launchpad.html](http://www.mathworks.com/academia/student_center/tutorials/launchpad.html)



## MATLAB DOs and DON'Ts

<http://nanohub.org/resources/1279>

