# MATLAB
# for REU/REV
# 2011

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# I assume

- Basic knowledge of computer
  - File system (create files, directories, etc.)
  - Use a text editor, like notepad (not word processor)
- Basic knowledge of linear algebra
  - scalar versus matrix
  - matrix operations

# In two hours you will

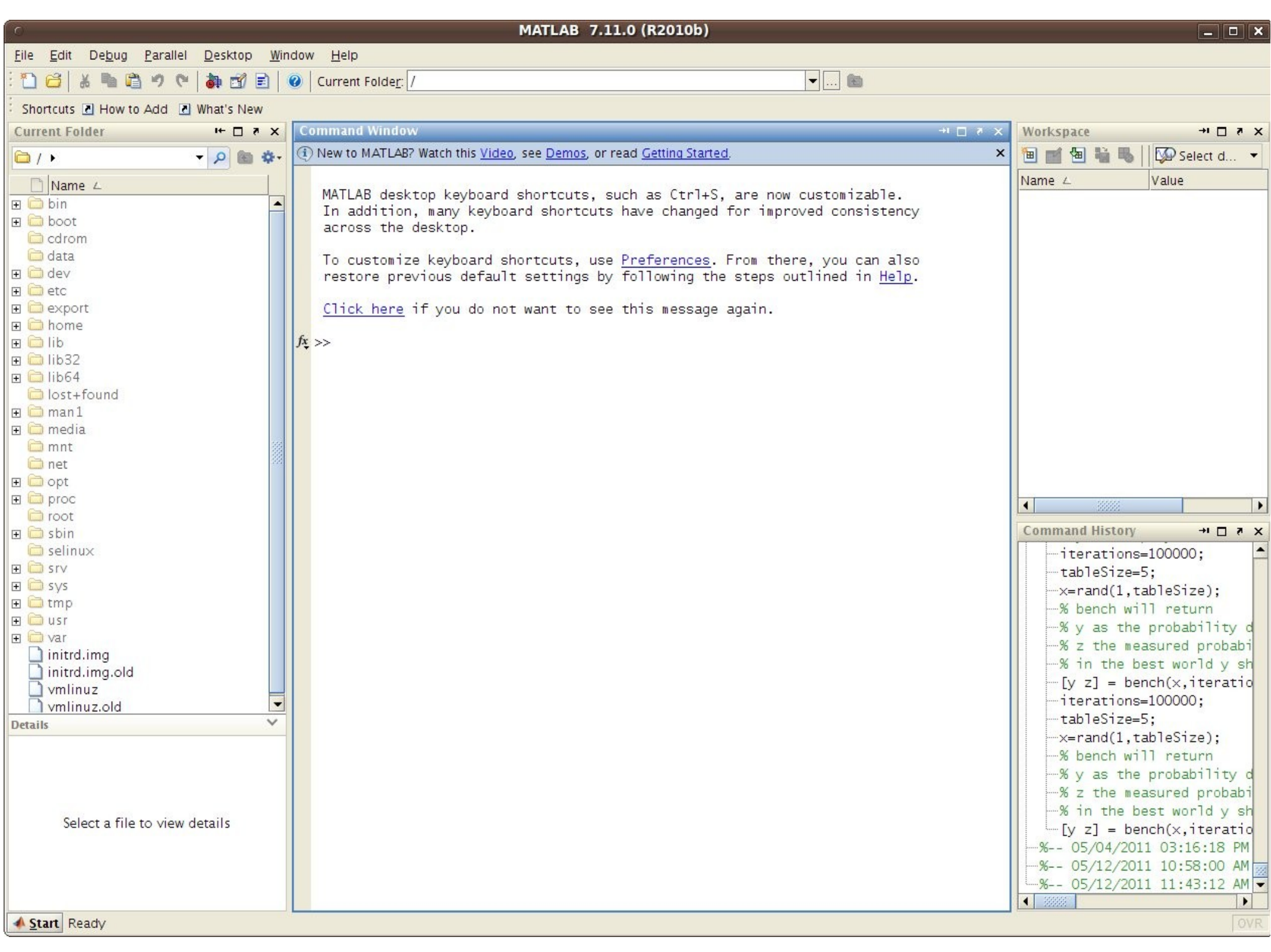
- be able to perform arithmetic operations
- have an understanding of vectorized operations
- be able to write simple program and functions
- plot graphs
- hungry enough to enjoy your lunch

# What is MATLAB?

- MATLAB = **MAT**rix **LAB**oratory
- High-level programming language
  - Easy to learn, make abstraction of internal computer machinery
- Command line based
  - Powerful, but not as intuitive as other programs

# Open MATLAB

- Windows
  - Start -> All Programs -> Matlab -> Matlab
- Linux/Mac
  - Open a terminal and write
    - **$ matlab &**


MATLAB 7.11.0 (R2010b)
File Edit Debug Parallel Desktop Window Help
Current Folder: /
Shortcuts How to Add What's New
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initrd.img
initrd.img.old
vmlinuz
vmlinuz.old
Details
Select a file to view details
Command Window
New to MATLAB? Watch this Video, see Demos, or read Getting Started.
MATLAB desktop keyboard shortcuts, such as Ctrl+S, are now customizable.
In addition, many keyboard shortcuts have changed for improved consistency
across the desktop.
To customize keyboard shortcuts, use Preferences. From there, you can also
restore previous default settings by following the steps outlined in Help.
Click here if you do not want to see this message again.
>>
Workspace
Select d...
Name
Value
Command History
iterations=100000;
tableSize=5;
x=rand(1,tableSize);
% bench will return
% y as the probability d
% z the measured probabi
% in the best world y sh
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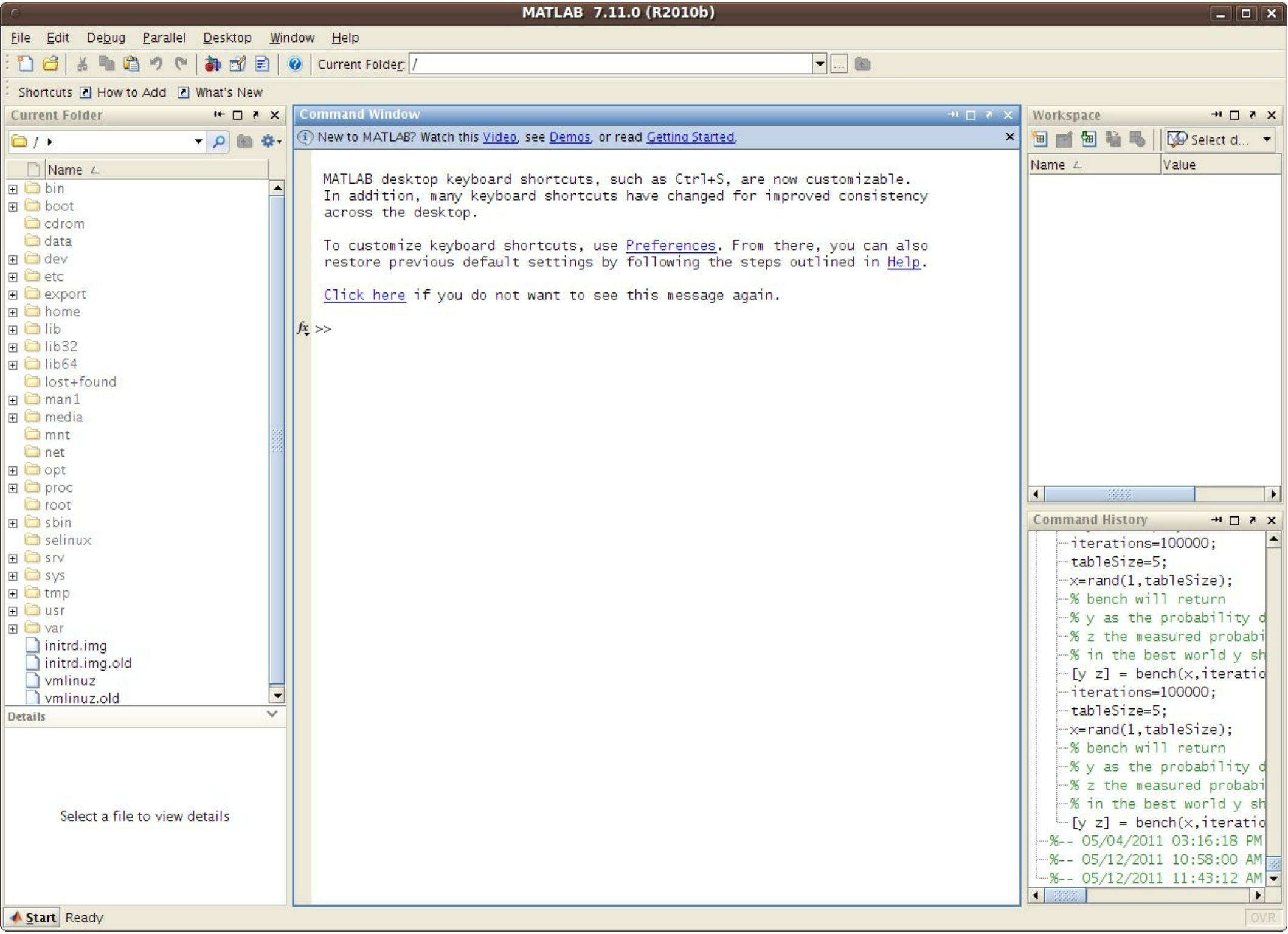
%-- 05/04/2011 03:16:18 PM
%-- 05/12/2011 10:58:00 AM
%-- 05/12/2011 11:43:12 AM
Start
Ready
OVR

# Where are you?

- Change the current folder
  - One project - one folder
  - **>> cd** *path*
  - Use the ... right next to the *current folder* address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# Getting started

- Use MATLAB as an expensive calculator
  - >> 1 + 2
  - >> 5 - 4
  - >> 4 * 4
  - >> 10 / 5
  - >> 2^9
  - >> log(100)

# Wait a minute

- $\log_{10}(100)=2$ why do I get 4.6?
- >> help log
  - The default is $\log_e(X)$ if I want $\log_{10}(X)$ I should use
  - >> log10(X)

# Single most important command

- >> help <what you are looking for>
- and its companion
- >> lookfor <what you are looking for>

# How MATLAB is different from a pocket calculator?

- You can save the output and use it later
- >> radius = 4/2
- >> area = pi * radius^2
- Exercise
  - Define a variable “circum” which computer the circumference of a circle

# Script file

- Prevent writing the same command over and over
- Good to keep track of what you do
- Ensure replicability, essential in science
- File -> New -> Script

# Script file

```
% This is a commentary. Everything after % is not interpreted by Matlab
% Compute area and circumference of circle, given the radius

rad=input('radius = '); % Input from command window
area = pi * rad^2       % No semicolon = output to command window
circum = 2*pi*rad
```

- Save it into the working directory under areaCirc.m
  - File -> Save (in the text editor window)
- To execute it type its file name without the “.m”
  - avoid unusual characters (!@#$%^&*~\+=.,<>{})
  - avoid space

# Matrix and vectors

- Row vector
  - >> x=[1 2 3] or
  - >> x=[1,2,3]
  - >> z=[2 1 sin(pi)]
  - >> w=[x z]
- Column vector
  - >> y=[2;1;5]

# Matrix and vector operations

- Addition
  - >> a=x+z
- Multiplication
  - >> a=x*z
  - oups!
  - >> a=x.*z
  - >> b=x*y

# Creation of vectors

- You cannot always afford to enter every value manually
  - Vector of one to one thousand by increment of one
  - >> x=[ 1 2 3 4 5 6 ... 1000];
  - Shortcut
  - >> x=linspace(1,1000,1000);
  - or
  - >> x=1:1:1000;
  - or
  - >> x=1:1000;

# Exercise

- Create a row vector 'b' 36 elements from 1 to 14
- Create a column vector 'c' of 14 elements from 14 to 30
- Combine vector b and c in a single row vector 'd'
  - Remember your linear algebra and use help/lookfor if you need it.

# Simple plot

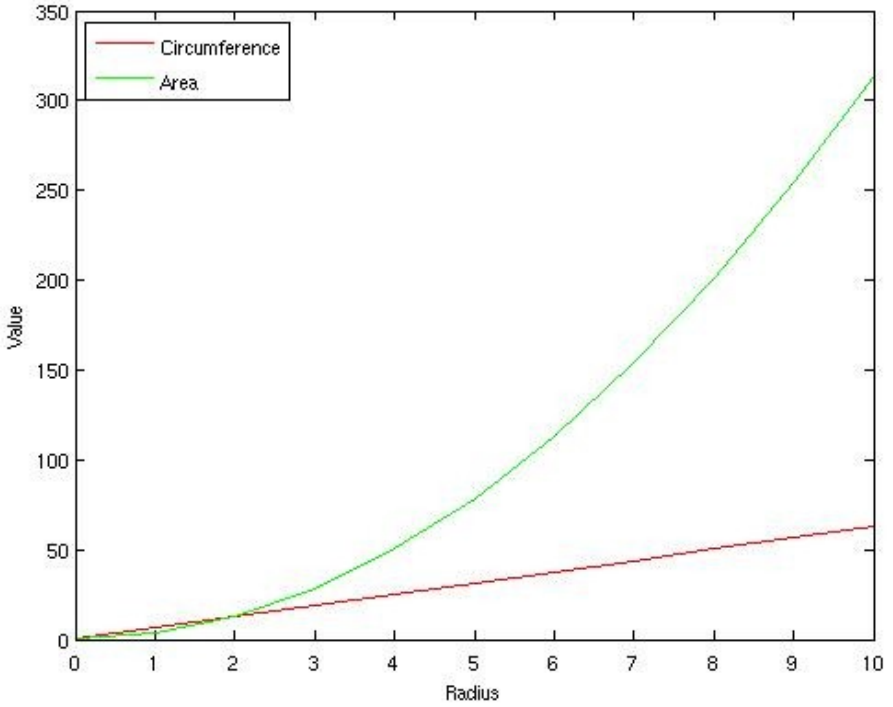
- Create a vector for the x axis
- >> x=0:0.1:4;
- Calculate the corresponding y values
- >> y=x.^3.*sin(x).^2;
  - No need for a loop!
- plot the figure
- >>plot(x,y)
- Axis labeling
- >>xlabel('x')
- >>ylabel('y')
- Add a title
- >> title('First figure')

# Save the graph

- Command line option
- >>  saveas(gcf,'test.eps','eps')
- >> saveas(gcf,'test.bmp','bmp')
- Click and follow instructions
  - File -> Save as ...

# Exercise

- Write a script file that plots area and circumference of a circle as a function of its radius. Use the following syntax to create a graph with two plots in different colors and symbols: plot(x,y,'r',x,z,'+')
  - You may want to learn more about the command legend



# Matrix 2D

- Matrix
  - >> A = [1 2 3 ; 4 5 6 ; 7 8 9]
  - Check the orientation (row filled first)
- Shortcut to create matrix
  - >> B=zeros(3,3)
  - zeros(number of rows, number of column)
  - >> C=ones(3,3)
- Access a specific element ($2^{nd}$ row, $3^{rd}$ column)
  - >> A(2,3)
- Access a single dimension
  - >> A(:,3)

# Simple matrix operation

- Transpose
  - D=A'
- Multiplication
  - >> A*D
  - Watch for dimension matching
- Element-wise multiplication
  - E=A.*D

# Leslie matrix

Age structured population with 4 classes $n_0$ $n_1$ $n_2$ $n_3$
Next time step there will be production of newborn $n_0$

$$n_0(t+1) = \sum_{i=0}^{3} f_i n_i(t)$$

There will be aging of everybody that survive

$$n_i(t+1) = s_{i-1} n_{i-1}(t)$$

How do we study the population age structure?

# Leslie matrix

$$n_0(t+1) = \sum_{i=0}^{3} f_i n_i(t) \qquad n_i(t+1) = s_{i-1} n_{i-1}(t)$$

$$\begin{bmatrix} n_0(t+1) \\ n_1(t+1) \\ n_2(t+1) \\ n_3(t+1) \end{bmatrix} = \begin{bmatrix} f_0 & f_1 & f_2 & f_3 \\ s_0 & 0 & 0 & 0 \\ 0 & s_1 & 0 & 0 \\ 0 & 0 & s_2 & 0 \end{bmatrix} \begin{bmatrix} n_0(t) \\ n_1(t) \\ n_2(t) \\ n_3(t) \end{bmatrix}$$

$$\boldsymbol{n}(t+1) = \boldsymbol{L}\,\boldsymbol{n}(t)$$

Lets say we have f, s and n

$$\begin{bmatrix} n_0(1) \\ n_1(1) \\ n_2(1) \\ n_3(1) \end{bmatrix} = \begin{bmatrix} 1.6 & 1.5 & 0.25 & 0.1 \\ 0.8 & 0 & 0 & 0 \\ 0 & 0.5 & 0 & 0 \\ 0 & 0 & 0.25 & 0 \end{bmatrix} \begin{bmatrix} 60 \\ 50 \\ 40 \\ 50 \end{bmatrix}$$

Find the population distribution for the next generation.

Find the population age structure after a million generations (Remember your linear algebra!)

# Eigenvalues - eigenvectors

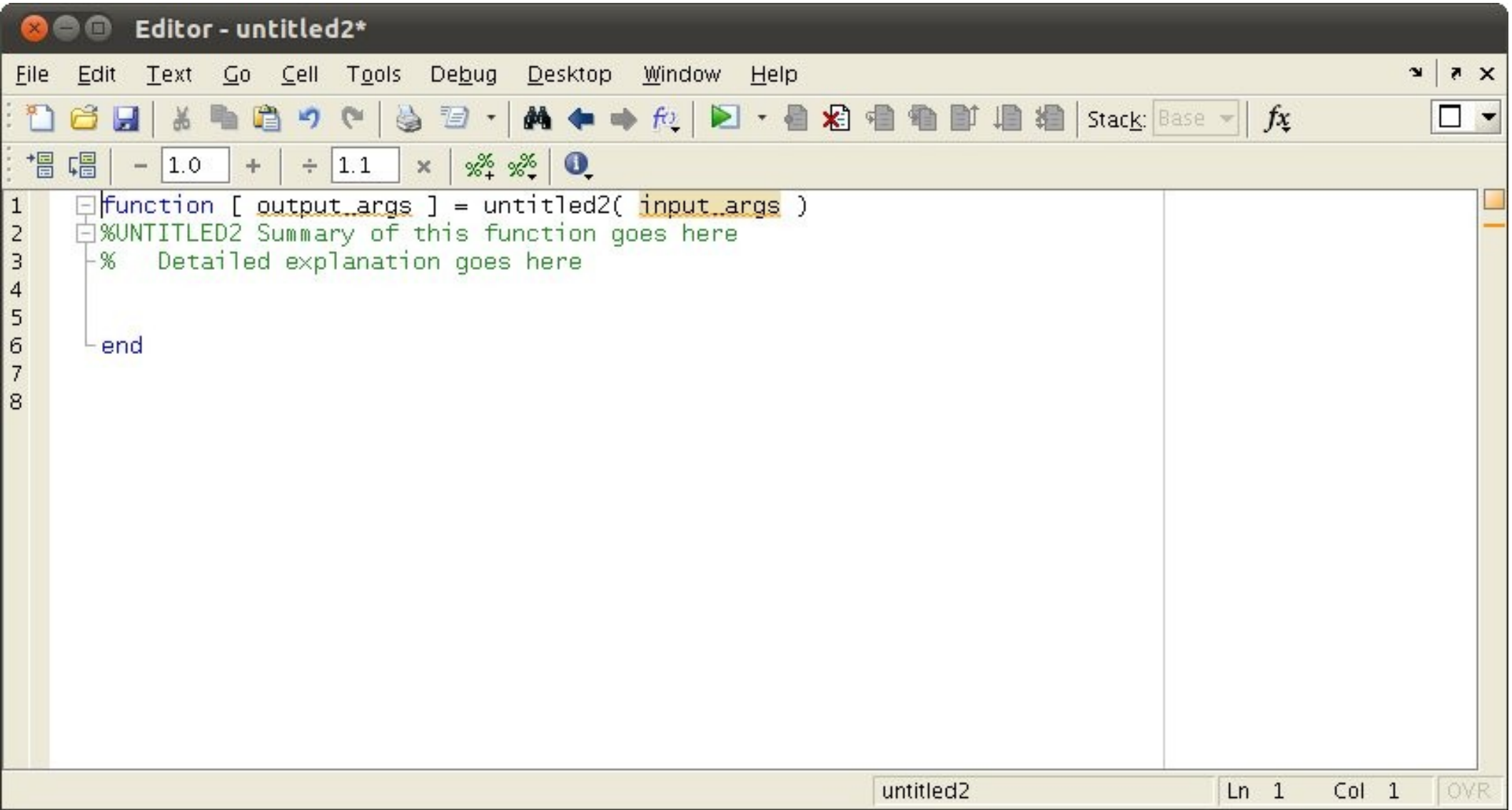
- Eigenvalue of a matrix
  - >>eig(L)
- Eigenvalue and eigenvector
  - >> [V,D] = eig(L)

# Functions

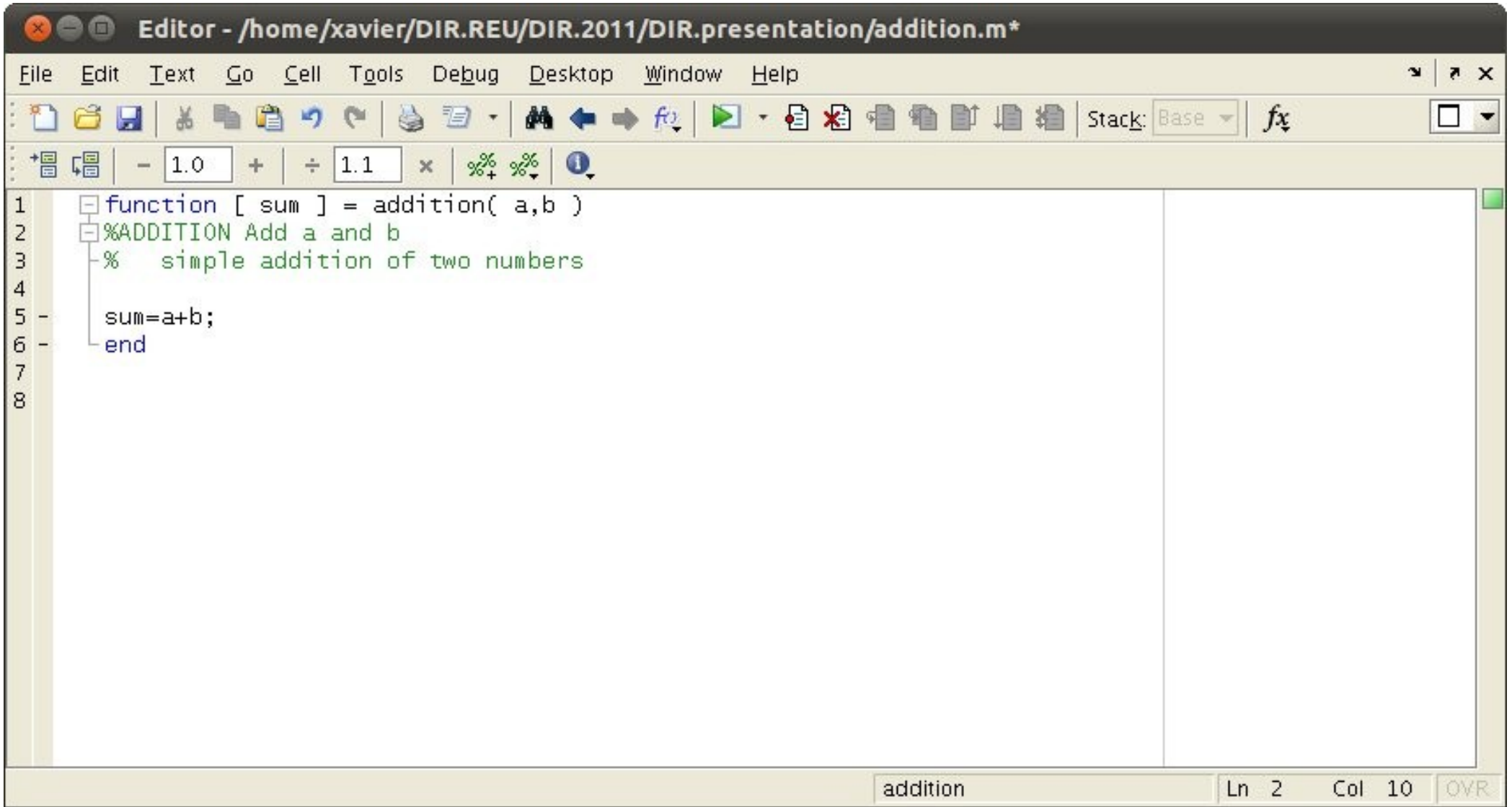
- eig is a function
- [output1, output2, ...] = functionName(input1, input2, ...)
- A function is a black box that (usually) does what we want
- We can create our own function for everything that we may have to repeat

# Simple function example

- File -> New -> Function



# Simple function example



# Use your new function

- Save the function in the working directory
  - name of the function should be the name of the file
- Call your function like any other function
  - >> addition(2, 2)
  - >> result = addition(2, 2)

# Read file

- Download lvData.csv from website http://nimbios.org/~xavier/REU/
- Read csv file
- >> M=csvread('lvData.csv');
- Plot your column 1 as a function of column 2

# Control flow

- for
  - Repeat something a fix number of time
- if
  - Conditional statement
- while
  - Repeat operation until a specific state

# Control flow

- To repeat operation several time
- Example: sum all integer from 1 to 10
- >> j=0;
- >> for i=1:10
- >> j=j+i;
- >> end
- If you are mathematician, you know that

$$\sum_{i=i}^{N} i = \frac{N(N+1)}{2}$$

# Control flow

- Exercise find the first 100 number of the Fibonacci sequence
- $F_i = F_{i-1} + F_{i-2}$
- $F_1 = F_2 = 1$
- Hint: use a vector to store your answer

# Control flow

- Simulate a logistic growth and write a function that return the time series for a given r (growth rate) and for a given number of iterations
-
- $$x_t = r\, x_{t-1}\left(1 - x_{t-1}\right)$$
-
- Hint: use a vector to store your answer
- Hint2: x1 should be near one, but not equal to one and r should be between 1 and 4

# Control flow

- Conditional statement
- Is the number odd or even?
- >> x=4;
- >> if (mod(x,2) == 0)
- >>  'even'
- >>else
- >>  'odd'
- >>end

# Control flow

- Conditions
- a == b  is a equal to b
- a  <  b  is a smaller than b
- a  >  b  is a greater then b
- a <= b  is a smaller or equal than b
- a >= b  is a greater or equal than b
- a ~= b  is a different than b

# Control flow

- Combination of conditions
- A && B  True if A and B are true
- A || B  True if at least A or B is true
- xor(A,B)  True only if one of A or B is true (exclusive)

# Control flow

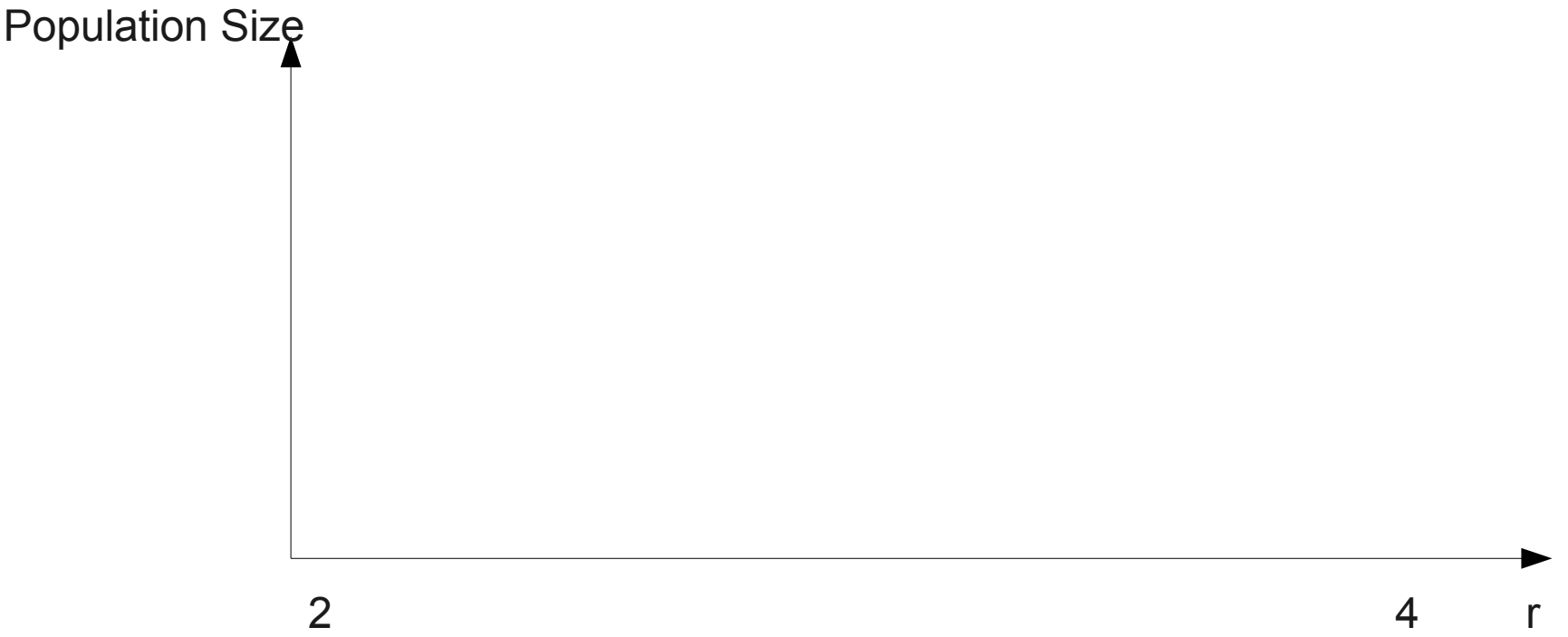
- Exercise: write a function that return if a number is positive and odd (single answer).

# Control flow

- A mix of repetition and condition
- >> i=10;
- >> while (i > 0)
- >>  i=i-1;
- >> end

# Synthesis problem

- Write a script that use your function for the logistic growth to study the behavior of population size at 'equilibrium'



# Synthesis problem

- 2<= r <= 4 (0.001 increment)
- 1000 iteration burn in for a 10 000 iteration simulation
- Check the function unique
- Plot dot and not lines

# Wrap up

- help is the most useful command
- lookfor is also very useful
- If not there is Internet (look for Matlab and your question/keywords)
- Cheat sheet
  - Find one first, them make your own
- Always use an editor to track your work

Thank you!