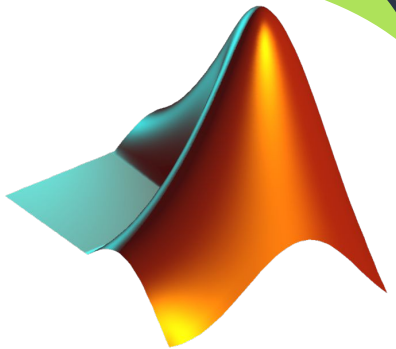
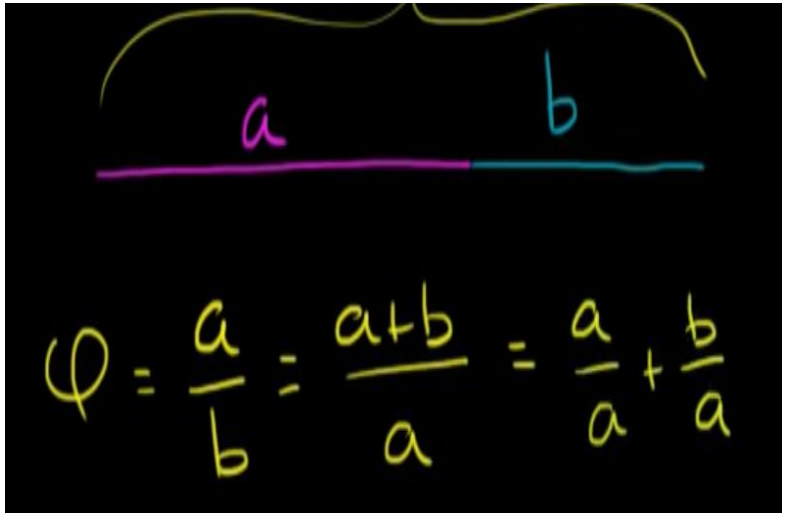
MATLAB MASTERY 2.0

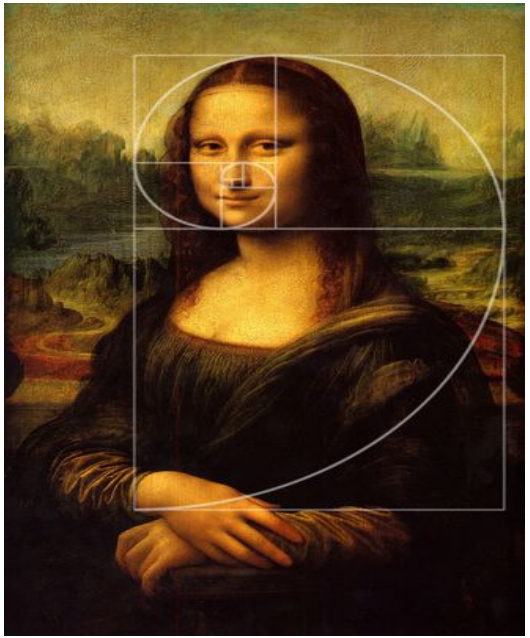


Sayan Mondal
EE Sophomore NIT'D

The Golden ratio

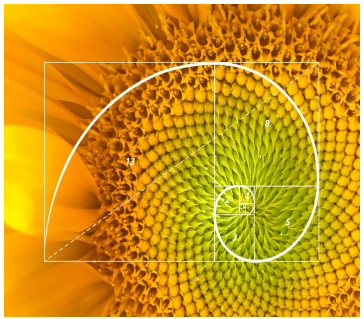


$$x^2 - x - 1 = 0$$



The Fibonacci

Let's start by plotting the Fibonacci series : ***The Nature's Code !!!***



The legend of Fibonacci !!!

The Fibonacci sequence was first introduced to the west by the Leonardo of Pisa in 1202 in his book Liber Abaci (Book of Calculation).

> *Because the above written pair in the first month bore, you will double it; there will be two pairs in one month.*
> *One of these, namely the first, bears in the second montth, and thus there are in the second month 3 pairs;*
> *of these in one month two are pregnant and in the third month 2 pairs of rabbits are born, and thus there are 5 pairs in the month;*
> ...
> *there will be 144 pairs in this [the tenth] month;*
> *to these are added again the 89 pairs that are born in the eleventh month; there will be 233 pairs in this month.*
> *To these are still added the 144 pairs that are born in the last month; there will be 377 pairs, and this many pairs are produced from the abovewritten pair in the mentioned place at the end of the one year.*

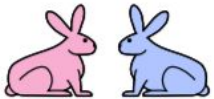
The legend

- Fibonacci numbers
  - Leonardo of Pisa (aka Fibonacci) modeled the following challenge
    - Newborn pair of rabbits (one female, one male) are put in a pen
    - Rabbits mate at age of one month
    - Rabbits have a one month gestation period
    - Assume rabbits never die, that female always produces one new pair (one male, one female) every month from its second month on.
    - How many female rabbits are there at the end of one year?

The Fibonacci sequence

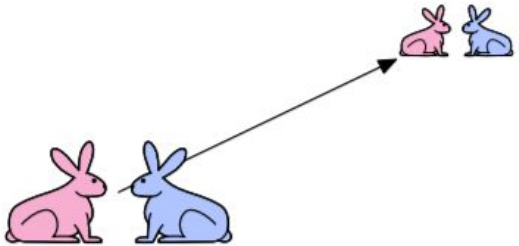
1

FIBONACCI



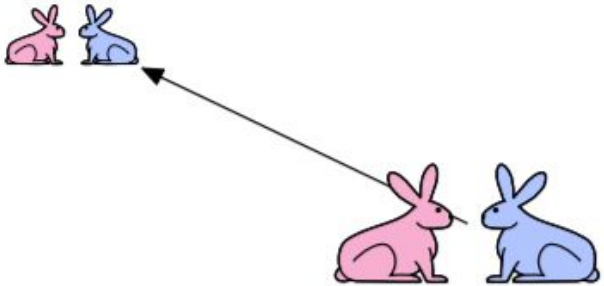
2

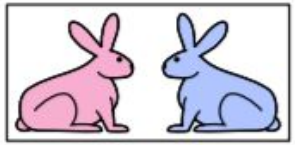
fibonacci



3

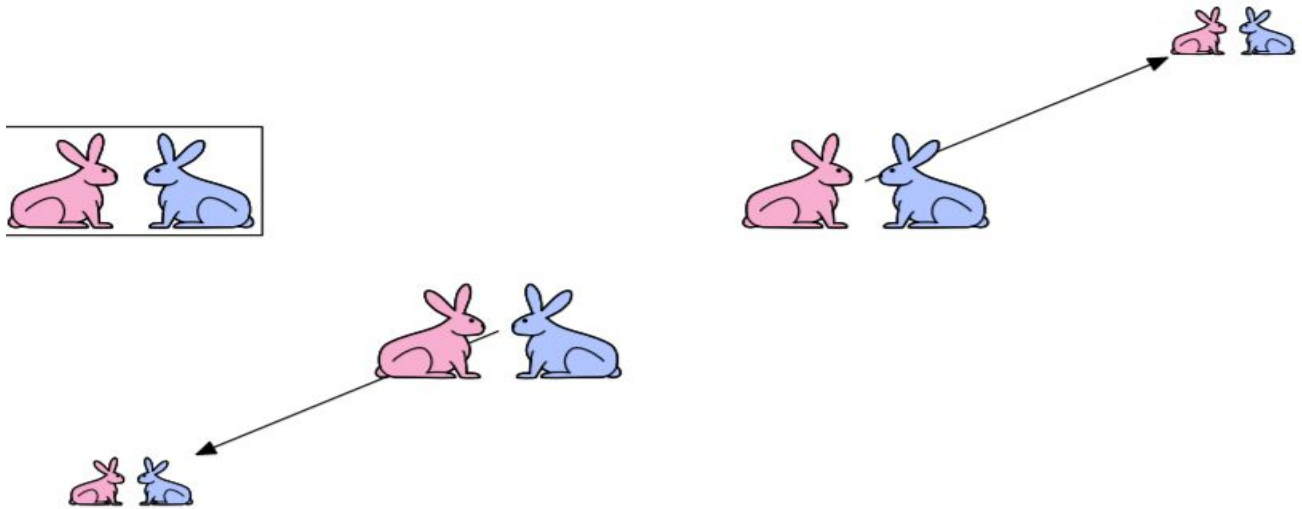
fibonacci





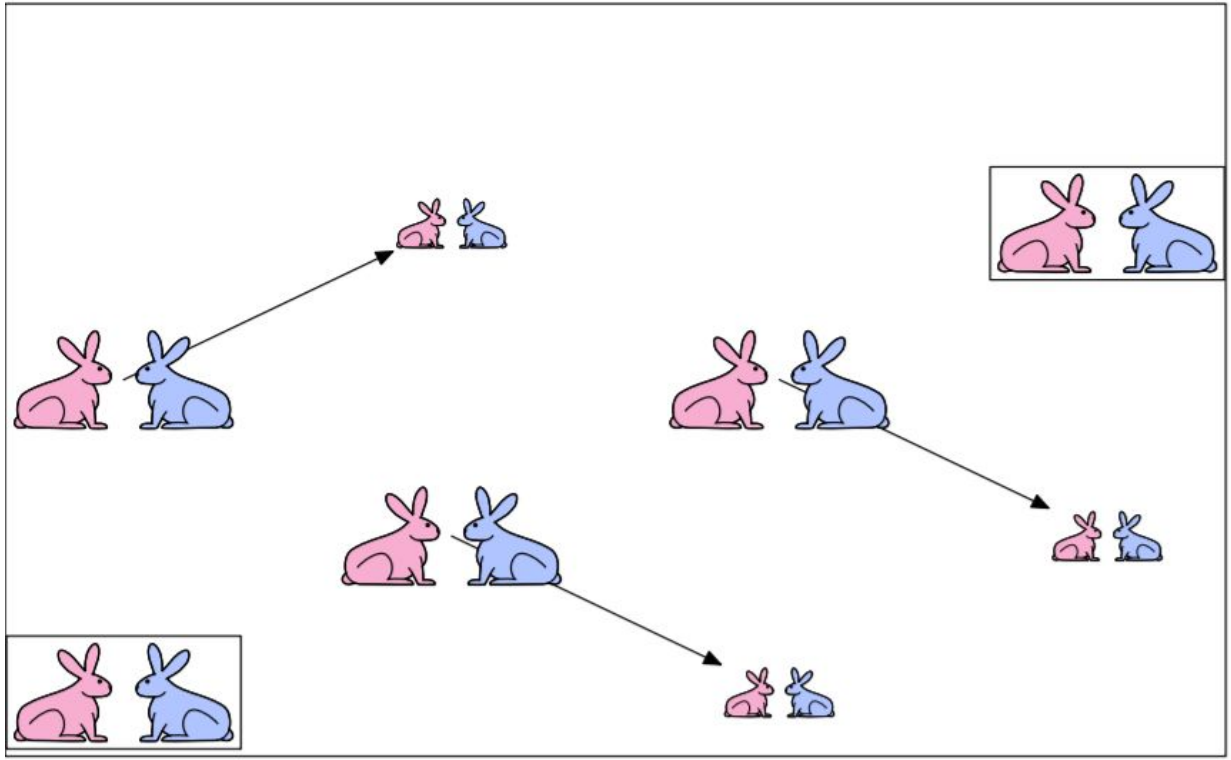
4

fibonacci

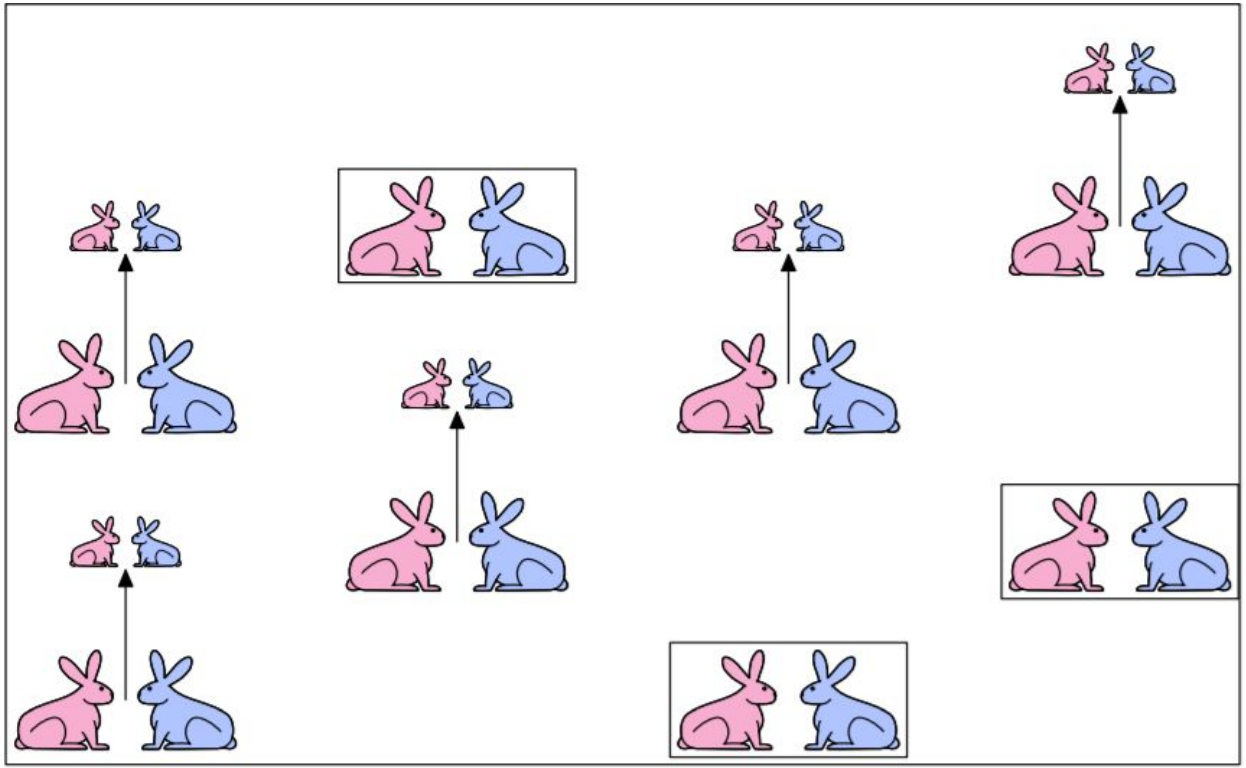


5

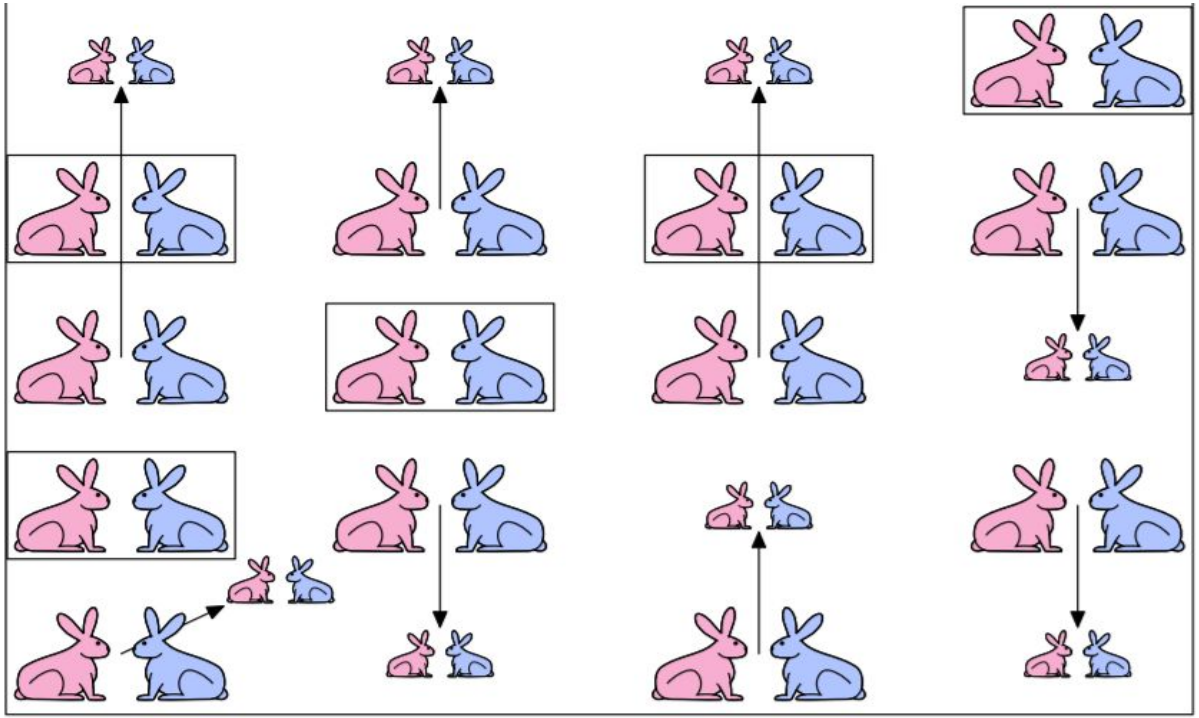
Fibonacci



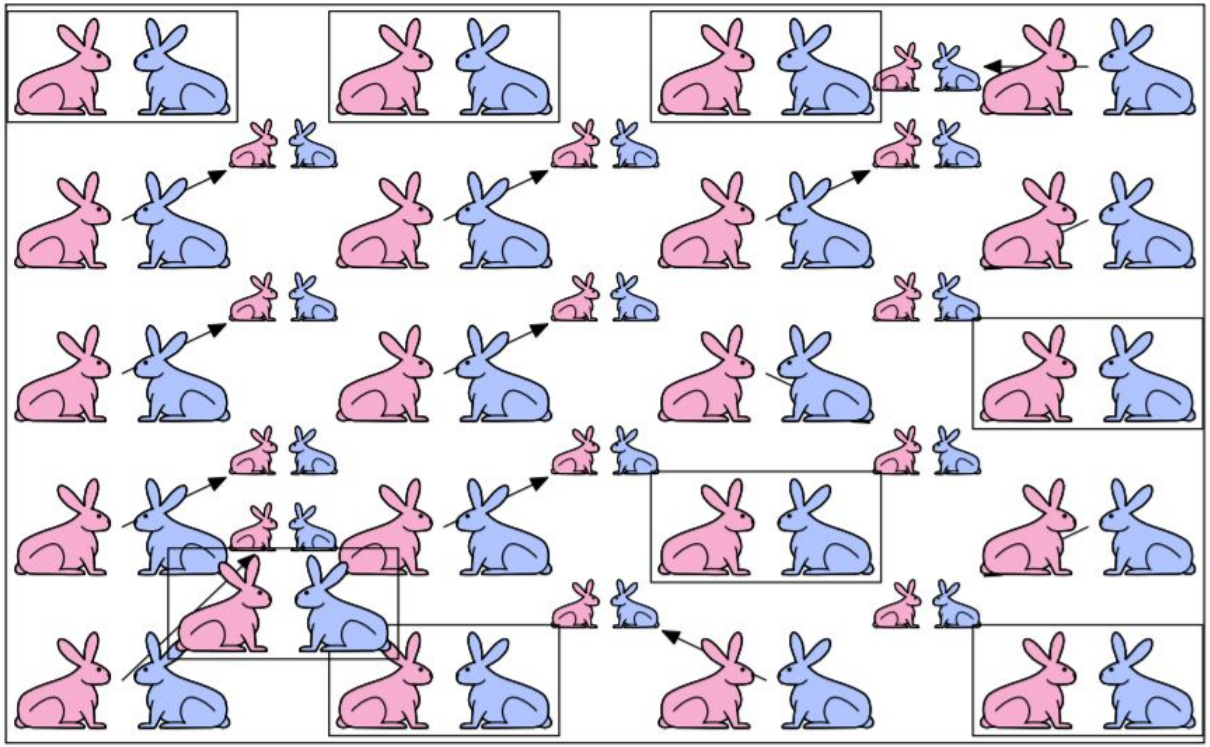
Fibonacci



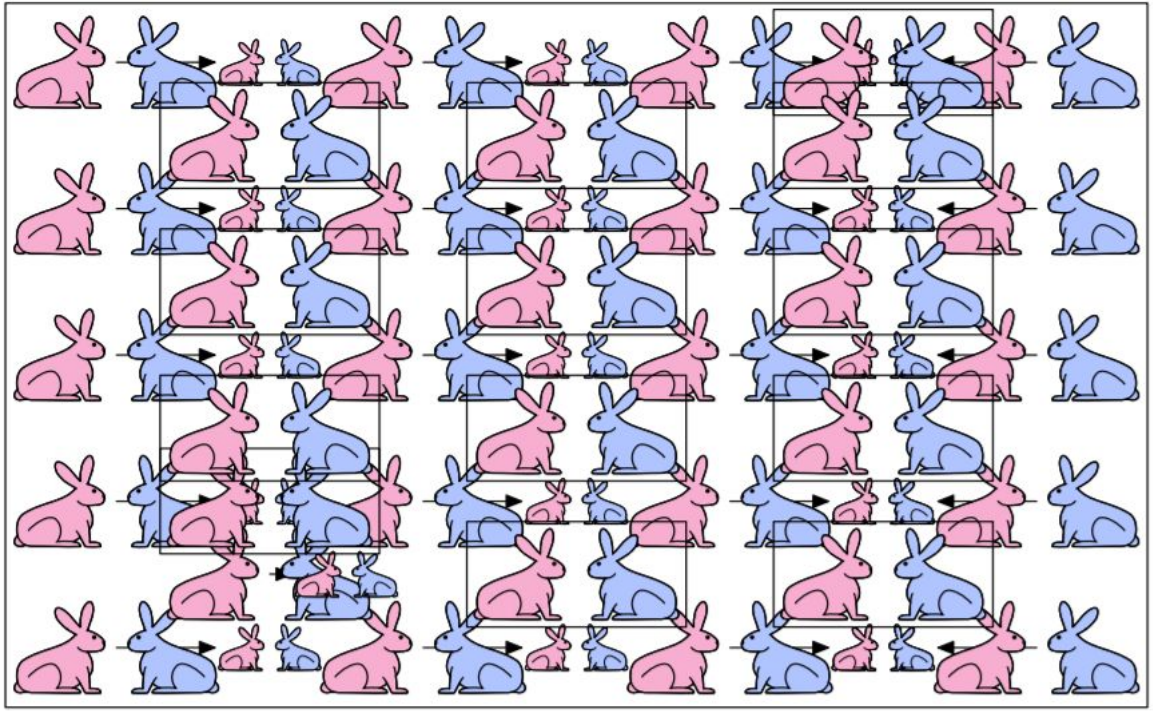
Fibonacci



Fibonacci



Fibonacci



We reach Australia !!!

FIBONACCI

After one month (call it 0) – 1 female

After second month – still 1 female (now pregnant)

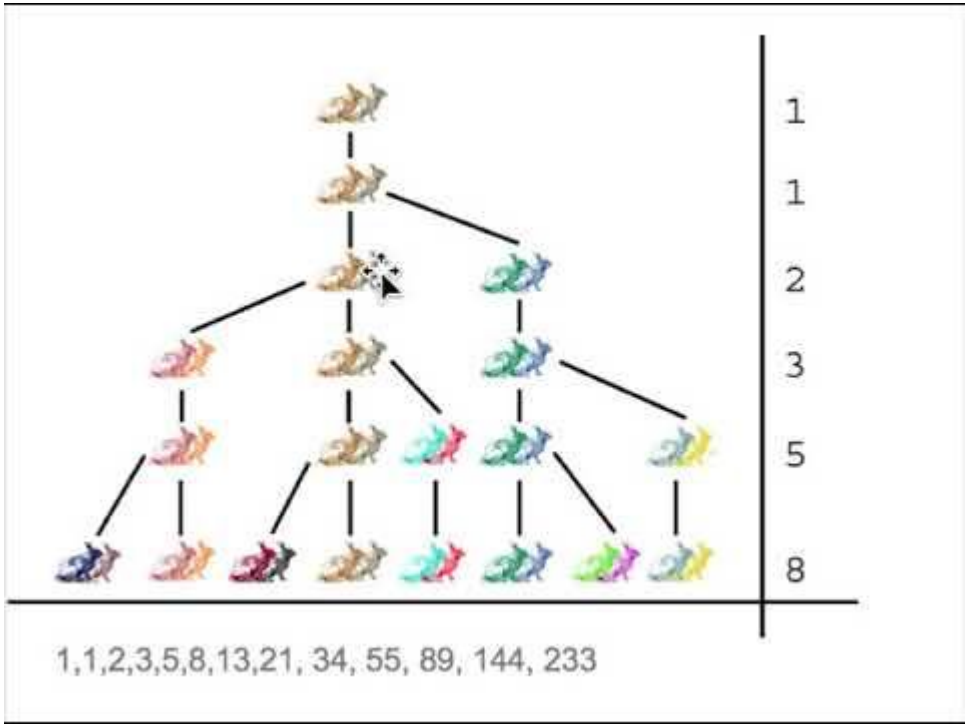
After third month – two females, one pregnant, one not

In general, females(n) = females(n-1) + females(n-2)

- Every female alive at month n-2 will produce one female in month n;
- These can be added those alive in month n-1 to get total alive in month n

Month	Females
0	1

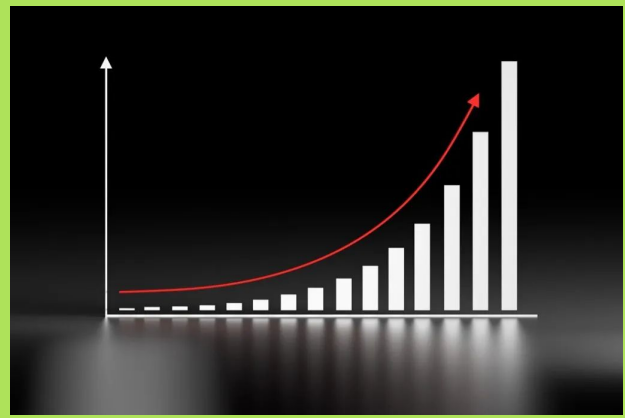
The fibonacci series



The fibonacci rabit

Let's get back to Matlab & Plotting !!!

Fibonacci #s grows at an Exponential rate !!!!



Numbers tell a story !!!

Content

- ✗ Function Calls to make life easier !!!
- ✗ Docs to the rescue !!
- ✗ Data Analysis with plots
- ✗ Power of Data Structure

Files in MATLAB

- Type "edit <fileName>" at the command prompt to open MATLAB code editor with the file fileName.m.
- MATLAB files are of two types: Scripts and Functions
- More help from MATLAB website on "Writing a MATLAB Program":

http://in.mathworks.com/videos/writing-a-matlab-program-69023.html

Scripts vs functions

- **Scripts**

  Files containing sequence of MATLAB commands

- MATLAB statements are executed as if typed on command prompt

- **Functions**

  Files that take certain input(s), executes sequence of steps, and returns output(s) at the end

- MATLAB statements are executed in function's own variable space

SCOPE

- `script` shares the variables with workspace from where it was called
- Typically, that means MATLAB workspace

- `function` has its own workspace
- Variables used in a function have local scope
- Functions "talk" through input and output variables:

```
[out1,out2,...] = function fcnName(in1,in2,...)
```

When to use what ?

- Use scripts when you want to…
  - Make small calculations (e.g., factorial, plotting, basic computing etc.)
- Use functions when you want to…
  - Calculate values (r) as a function of variables (t,y,…): $r = f(t, y, \ldots)$
  - Pass on the function values to MATLAB function for solving something; e.g.,:

$\frac{dy}{dt} = f(t,y)$ → `function dy = myODEfun(t,y)`

`<...>ode45(@myOdefun, <...>)`

  - Calculate properties as a function of temperature, concentration, current, etc.
- All other purposes, you are likely to use scripts (instead of functions)

1

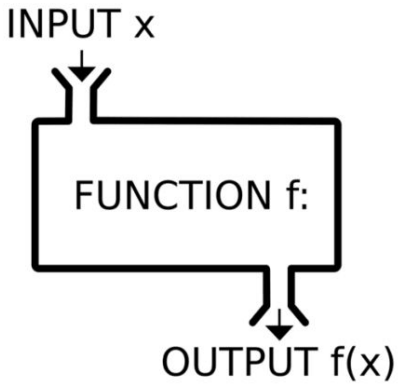
Function Calls

MATLAB provides a large number of functions that perform computational tasks. Functions are equivalent to subroutines or methods in other programming languages.

Function Calls

- To call a function, such as max, enclose its input arguments in parentheses max(A)
- If there are multiple input arguments, separate them with commas:

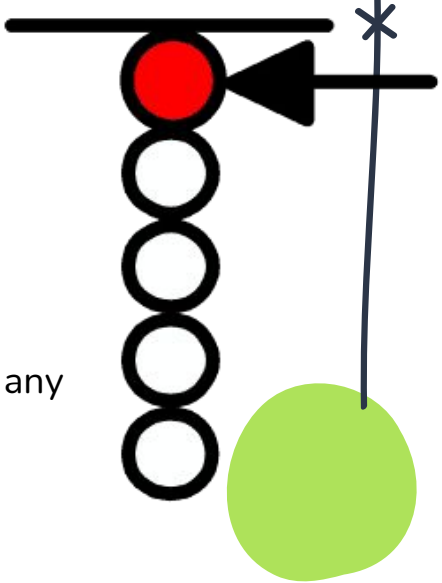
  max(A,B)
- Return output from a function by assigning it to a variable
- When there are multiple output arguments, enclose them in square brackets:
- To call a function that does not require any inputs and does not return any outputs, type only the function name: eg- clc



The Max Function

- To call a function, such as max, enclose its input arguments in parentheses
  max(A)
- If there are multiple input arguments, separate them with commas:

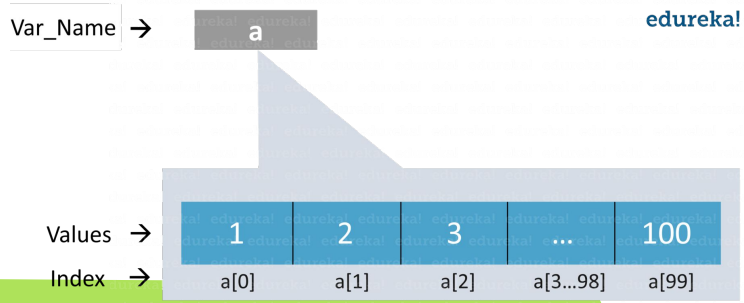
  max(A,B)
- Return output from a function by assigning it to a variable
- When there are multiple output arguments, enclose them in square brackets:
- To call a function that does not require any inputs and does not return any outputs, type only the function name: eg- clc



The Max Function

- The maximum value of a vector and its corresponding index value can be determined using the max function.
- The first output from the max function is the maximum value of the input vector. When called with two outputs, the second output is the index value.
- When called with two outputs, the second output is the index value
- If you only need the second output from a function, you can use a tilde (~) to ignore specific outputs.

```
[~,ivMax] = max(v2)
```



Some Built in functions

2 FUNCTIONS

- **Linspace**

`y = linspace(x1,x2,n)` generates `n` points. The spacing between the points is `(x2-x1)/(n-1)`.

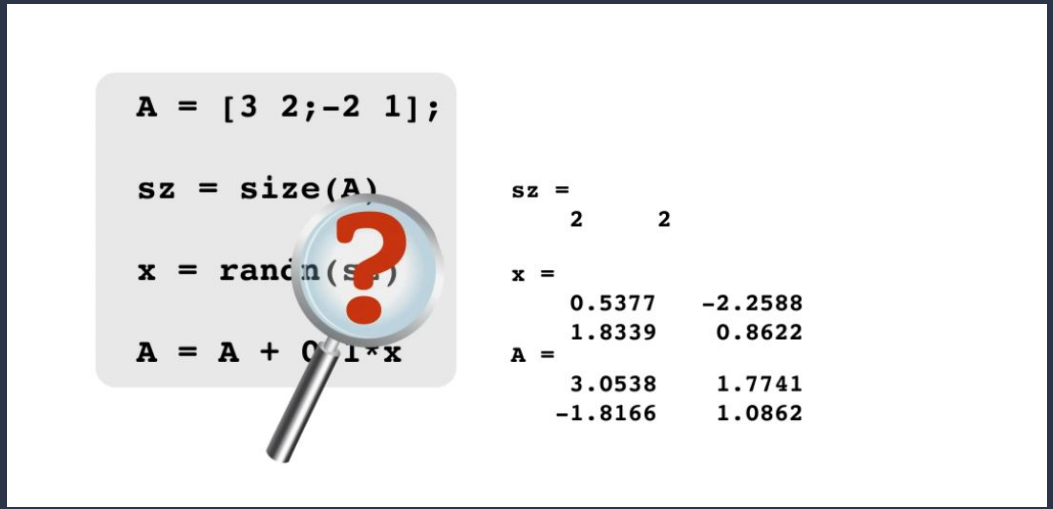
- **Randn**

`X = randn(n)` returns an `n`-by-`n` matrix of normally distributed random numbers.

2

Obtaining Help !!!

Use the MATLAB documentation to discover information about MATLAB features.



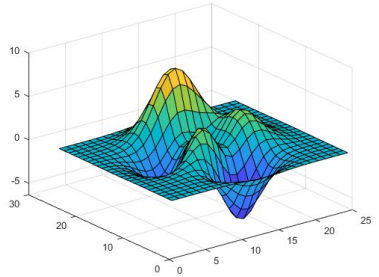
Suppose you find something in an open source repo which you haven’t came across before

You can open the documentation using the doc function.
Try opening the documentation for randi with the code below:

doc randn

2

Plotting Data



- Visualize variables using MATLAB's plotting functions.
  - Plotting Vectors
  - Annotating Plots
  -

COMPUTER ALGEBRA

- Numeric Computation
  - involve numbers directly
  - manipulate numbers to produce a numerical result

Example (numerical)

$$\frac{(17.36)^2 - 1}{17.36 + 1} = 16.36$$

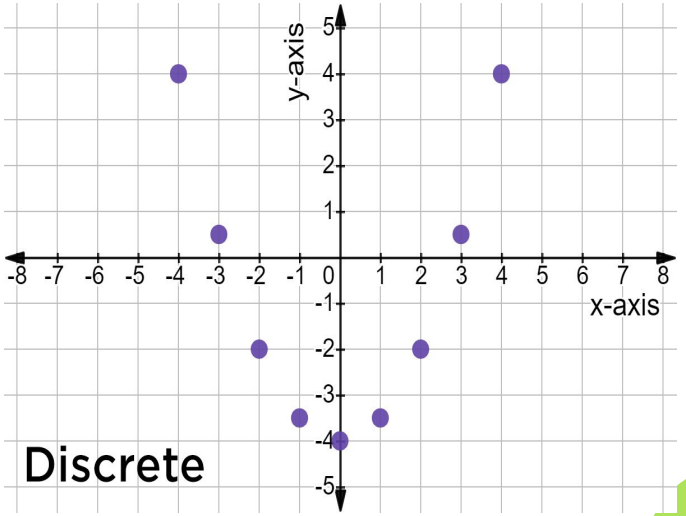
- Symbolic Computation
  - symbols represent numbers
  - manipulate symbols according to mathematical rules to produce a symbolic result

Example (symbolic)

$$\frac{x^2 - 1}{x + 1} = x - 1$$

Numerical computation

- Create a Grid/Mesh on X
- Calculate the function value on all the grid points
- Plot the those values as discrete points and join them



Let's plot the Fibonacci !!!

Plotting

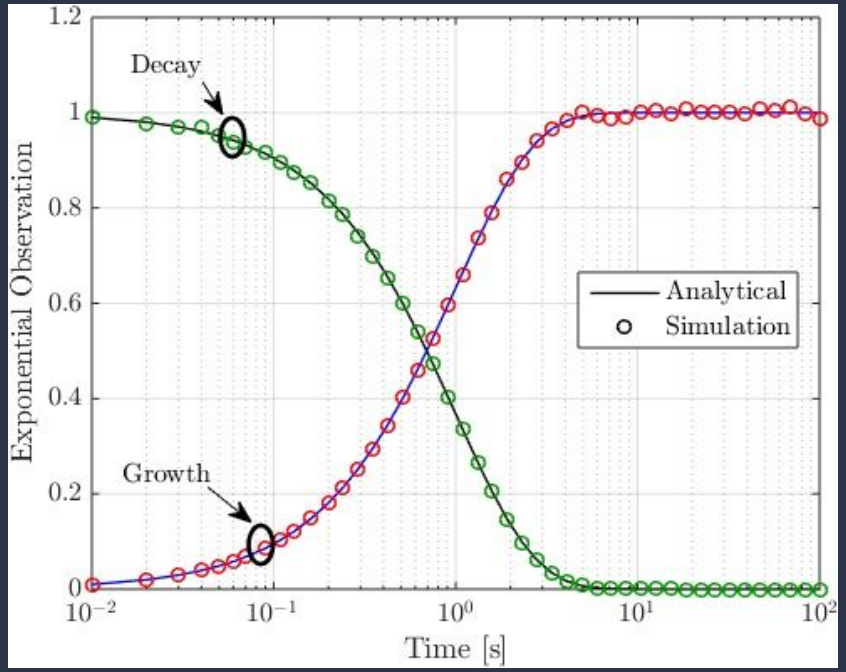
- Two vectors of the same length can be plotted against each other using the plot function → **plot(x,y)**
- The plot function accepts an additional argument that allows you to specify the color, line style, and marker style using different symbols in single quotes → **plot(x,y,"r--o")**
- The command above plots a red (r) dashed (--) line with a circle (o) as a marker.
- You can learn more about the symbols available in the documentation for Line Specification.

Plotting

- Notice that each plot command created a separate plot. To plot one line on top of another, use the **hold on** command to hold the previous plot while you add another line.
- While the hold state is on, plots will continue to go on the same axes. To return to the default plot behavior, where each plot gets its own axes, enter hold off.

Plotting

- When you plot a single vector by itself, MATLAB uses the vector values as the y-axis data and sets the x-axis data to range from 1 to n (the number of elts. in the vector).
- The plot function accepts optional additional inputs consisting of a property name and an associated value. → **plot(y,"LineWidth",5)**
- The command above plots a heavy line.
- You can provide additional inputs to the plot function after the line specifier. → **plot(x,y,"ro-","LineWidth",5)**
- You can learn more about available properties in the documentation for Line Properties.



ANNOTATING PLOTS

Annotating Plots

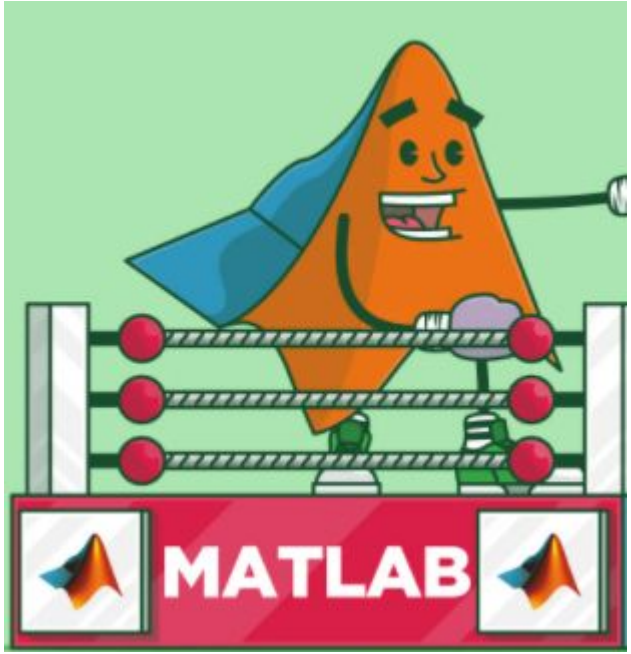
- Labels can be added to plots using plot annotation functions, such as title. The input to these functions is a string. Strings in MATLAB are enclosed in double quotes (").

title("Plot Title")

- Use the ylabel function to add the label **"Mass (g)"**.
- You can add a legend to your plot using the legend function.

legend("a","b","c")

- But how to draw complex functions
- Do we need loops and stuff !!!

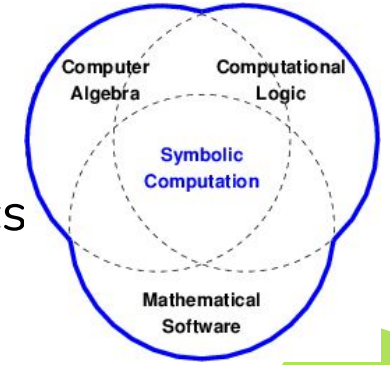


Matlab to the Rescue !!!

Symbolic computing

- Symbolic computation refers to development of algorithms for manipulating mathematical expressions and other mathematical objects.

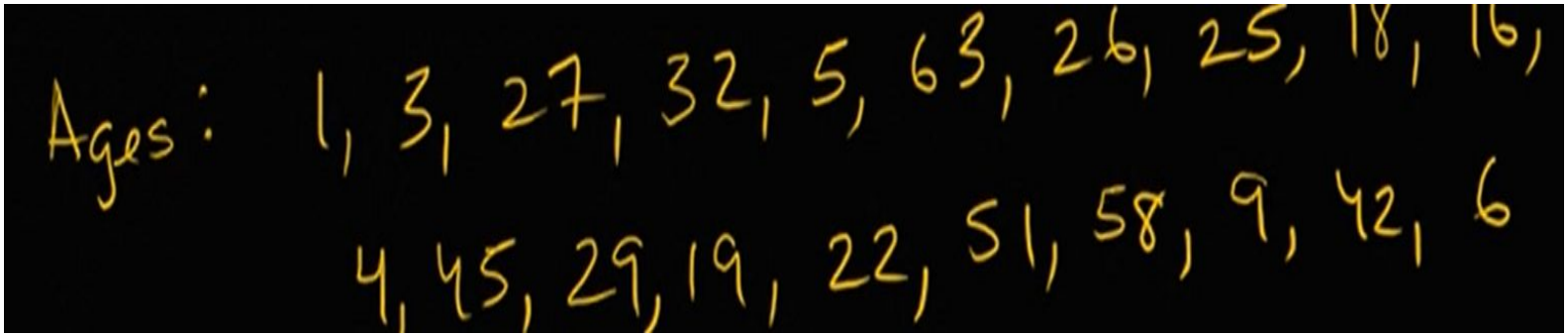
- Symbolic computation integrates mathematics with computer science to solve mathematical expressions using mathematical symbols.



Probability distribution

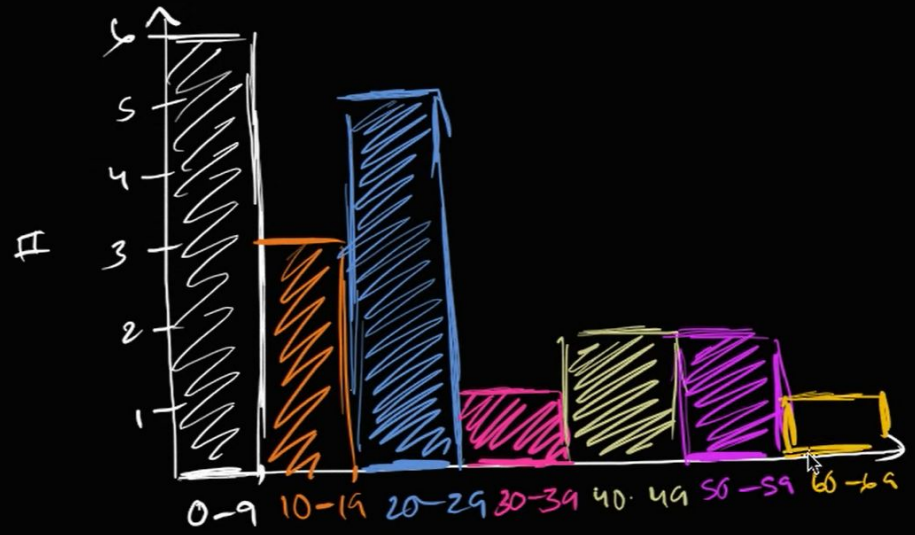
- A probability distribution is a statistical function that describes all the possible values and likelihoods that a random variable can take within a given range.
- This range will be bounded between the minimum and maximum possible values, but precisely where the possible value is likely to be plotted on the probability distribution depends on a number of factors.
- These factors include the distribution's mean (average), standard deviation, skewness, and kurtosis.

Histogram

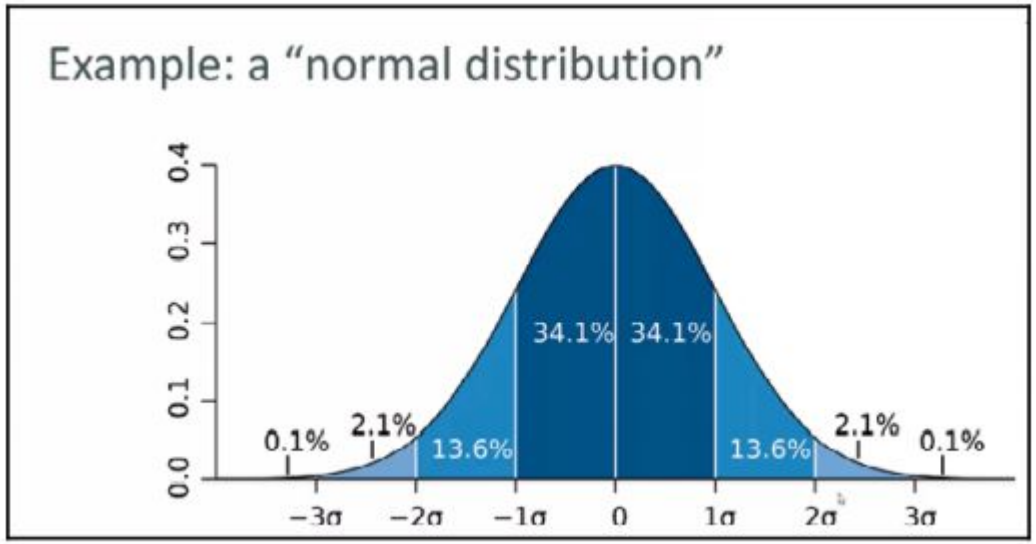


Histogram

Bucket	#
0 - 9	6
10 - 19	3
20 - 29	5
30 - 39	1
40 - 49	2
50 - 59	2
60 - 69	1

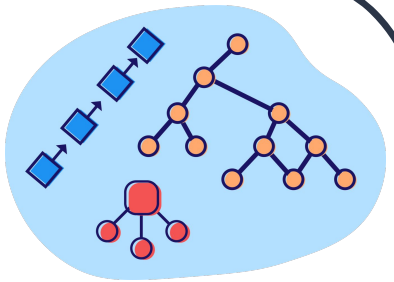


A NORMAL DISTRIBUTION



1. You can see in the graph, as you get close to the mean (0), within one standard deviation (-1σ and 1σ), you're pretty likely to land there. I mean, if you add up 34.1 and 34.1, which equals to 68.2%, you get the probability of landing within one standard deviation of the mean.
2. However, as you get between two and three standard deviations (-3σ to -2σ and 2σ to 3σ), we're down to just a little bit over 4% (4.2%, to be precise).
3. As you get out beyond three standard deviations (-3σ and 3σ) then we're much less than 1%.

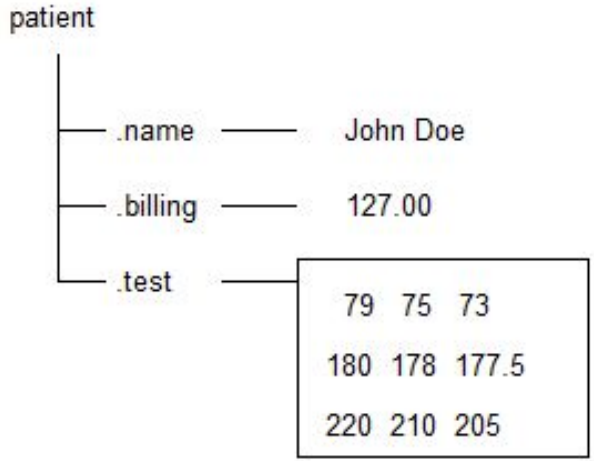
1



Data structure

Data Structure is a way to store and organize data so that it can be used efficiently.

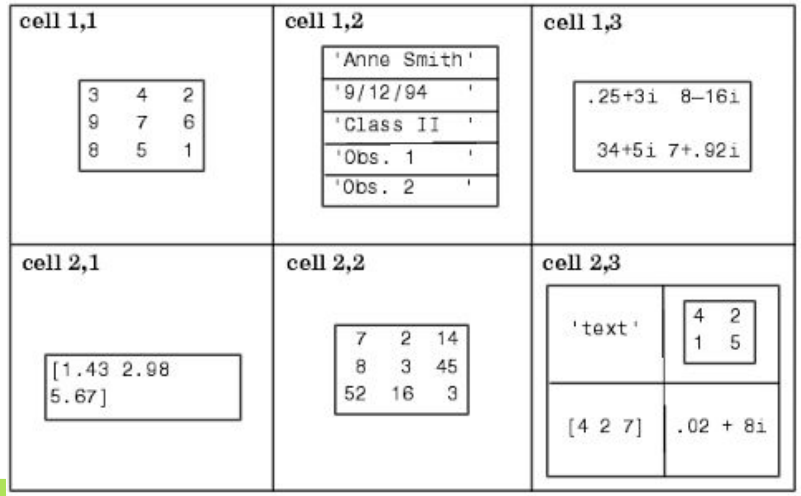
- A *structure array* is a data type that groups related data using data containers called *fields*. Each field can contain any type of data. Access data in a field using dot notation of the form `structName.fieldName`.



STRUCT

CELL

- A *cell array* is a data type with indexed data containers called *cells*, where each cell can contain any type of data.
- Refer to sets of cells by enclosing indices in smooth parentheses, `()`. Access the contents of cells by indexing with curly braces, `{}`.



Thanks!

Any questions?

You can find me at:

- https://www.linkedin.com/in/sa-y-an/
- sayanmondal@ieee.org

@Copyleft → Sayan Mondal

Further Studies

- **Problems in MATLAB**
  https://www.mathworks.com/matlabcentral/cody/groups/1110
- Exponential Growth Intuition https://youtu.be/U_6AYX42gkU?t=1430
- Numerical Computation in MATLAB
  https://nptel.ac.in/courses/103/106/103106118/
- Scientific Computing Using MATLAB
  https://nptel.ac.in/courses/111/102/111102137/
- Plots in MATLAB
  https://in.mathworks.com/help/matlab/creating_plots/using-high-level-plotting-functions.html
- MATLAB Onramp https://in.mathworks.com/learn/tutorials/matlab-onramp.html
- For any other help you can always refer to MATLAB Documentation
  https://in.mathworks.com/help/index.html

ACKNOWLEDGEMENTS

- The fibonacci rabbits slides are taken from Prof. Eric Grimson (MIT OCW) lectures https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-0001-introduction-to-computer-science-and-programming-in-python-fall-2016/index.htm

- The Files in MATLAB slides are taken from Prof. Niket Kaisare NPTEL Series (IIT Madras) https://nptel.ac.in/courses/103/106/103106118/