Bil 108

Introduction to the Scientific and Engineering Computing with MATLAB

Lecture 2

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Arrays

- MATLAB variables are arrays of numbers. An array consisting of one element is called a scalar.
- For example;

$$x = 2$$

x has the value 2.

- More commonly, x will assume a number of values, say from 0 to 5,

For example;

x = 1:0.5:5

Now x is an array of numbers;

x = [1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0]

Examples of arrays

- A = [1, 2; 3, 4; 5, 6]
  Creates a 3x2 array, 3 rows and 2 columns.
  The semicolon creates a new row.

- x = [4; 5]
- Creates an array with 2 rows and one column.
- x = 4
      5

Operations on arrays

- Addition and subtraction

$$A + B = \left[a_1 + b_1, a_2 + b_2, \ldots, a_n + b_n\right]$$

$$A - B = \left[a_1 - b_1, a_2 - b_2, \ldots, a_n - b_n\right]$$

- Multiplication and division

$$A.*B = \left[a_1 b_1, a_2 b_2, \ldots, a_n b_n\right]$$

$$A./B = \left[a_1 / b_1, a_2 / b_2, \ldots, a_n / b_n\right]$$

- Creating a vector with constant spacing by specifying the first and last terms, and the number of terms:

  - variable_name=linspace(xi,xf,n)

  - Eg.
    - A=linspace(30,10,11)

    - B=linspace(50,5)

      when the spacing is omitted the default for it is 100.

Defining Vectors in MATLAB

Assign any expression that evaluates to a vector

```
>> v = [1 3 5 7]

>> w = [2;4;6;8]

>> x = linspace(0,10,5);

>> y = 0:30:180

>> z = sin(y*pi/180);
```

- Distinguish between row and column vectors

- >> r = [1 2 3];% row vector
- >> s = [1 2 3]';% column vector
- >> r - s
- ??? Error using ==> -Matrix dimensions must agree.

- Although r and s have the same elements, they are not the
same vector. Furthermore, operations involving r and s are
bound by the rules of linear algebra.

Vector Addition and Subtraction

- Addition and subtraction are element-by-element operations
- $c = a + b \Leftarrow\Rightarrow c_i = a_i + b_i \; i = 1, \ldots, n$
- $d = a - b \Leftarrow\Rightarrow d_i = a_i - b_i \; i = 1, \ldots, n$

Example:

$$a = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix} \qquad b = \begin{bmatrix} 3 \\ 2 \\ 1 \end{bmatrix}$$

$$a + b = \begin{bmatrix} 4 \\ 4 \\ 4 \end{bmatrix} \qquad a - b = \begin{bmatrix} -2 \\ 0 \\ 2 \end{bmatrix}$$

Multiplication by a Scalar

- Multiplication by a scalar involves multiplying each element in
- the vector by the scalar:
- $b = \sigma a \Longleftrightarrow b_i = \sigma a_i \quad i = 1, \ldots, n$

Example:

$$a = \begin{bmatrix} 4 \\ 6 \\ 8 \end{bmatrix} \qquad b = \frac{a}{2} = \begin{bmatrix} 2 \\ 3 \\ 4 \end{bmatrix}$$

Vector Transpose

The *transpose* of a row vector is a column vector:

$$u = [1, 2, 3] \qquad \text{then} \qquad u^T = \begin{bmatrix} 1 \\ 2 \\ 3 \end{bmatrix}$$

Likewise if v is the column vector

$$v = \begin{bmatrix} 4 \\ 5 \\ 6 \end{bmatrix} \qquad \text{then} \qquad v^T = [4, 5, 6]$$

Linear Combinations

Combine scalar multiplication with addition

$$\alpha \begin{bmatrix} u_1 \\ u_2 \\ \vdots \\ u_m \end{bmatrix} + \beta \begin{bmatrix} v_1 \\ v_2 \\ \vdots \\ v_m \end{bmatrix} = \begin{bmatrix} \alpha u_1 + \beta v_1 \\ \alpha u_2 + \beta v_2 \\ \vdots \\ \alpha u_m + \beta v_m \end{bmatrix} = \begin{bmatrix} w_1 \\ w_2 \\ \vdots \\ w_m \end{bmatrix}$$

$$r = \begin{bmatrix} -2 \\ 1 \\ 3 \end{bmatrix} \qquad s = \begin{bmatrix} 1 \\ 0 \\ 3 \end{bmatrix}$$

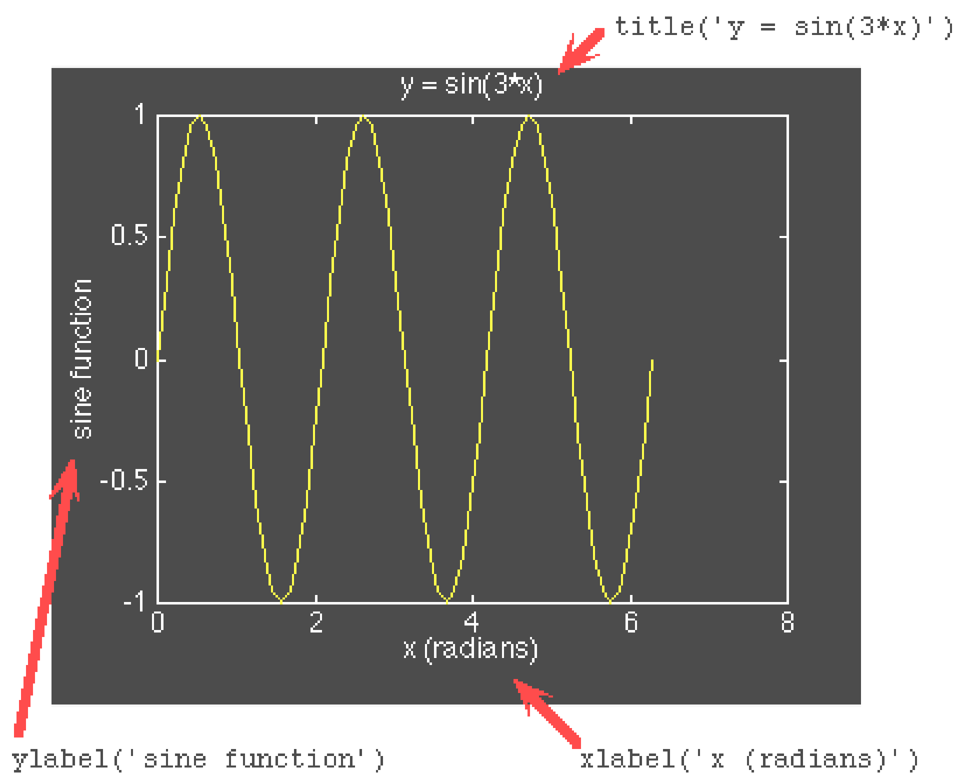
$$t = 2r + 3s = \begin{bmatrix} -4 \\ 2 \\ 6 \end{bmatrix} + \begin{bmatrix} 3 \\ 0 \\ 9 \end{bmatrix} = \begin{bmatrix} -1 \\ 2 \\ 15 \end{bmatrix}$$

Simple Plot

>> plot(xdata,ydata)

- X = [1 : 2 : 13];
- Y = 2*x + 5*x^2;   ???
- plot (X , Y)
- grid
- x label (‘time’)
- y label (‘2x+5x^2’)

- >> x = 0:pi/30:2*pi; % x vector, 0 <= x <= 2*pi, increments of pi/30
- >> y = sin(3*x); % vector of y values
- >> plot(x,y) % create the plot
- >> xlabel('x (radians)'); % label the x-axis
- >> ylabel('sine function'); % label the y-axis
- >> title('sin(3*x)'); % put a title on the plot

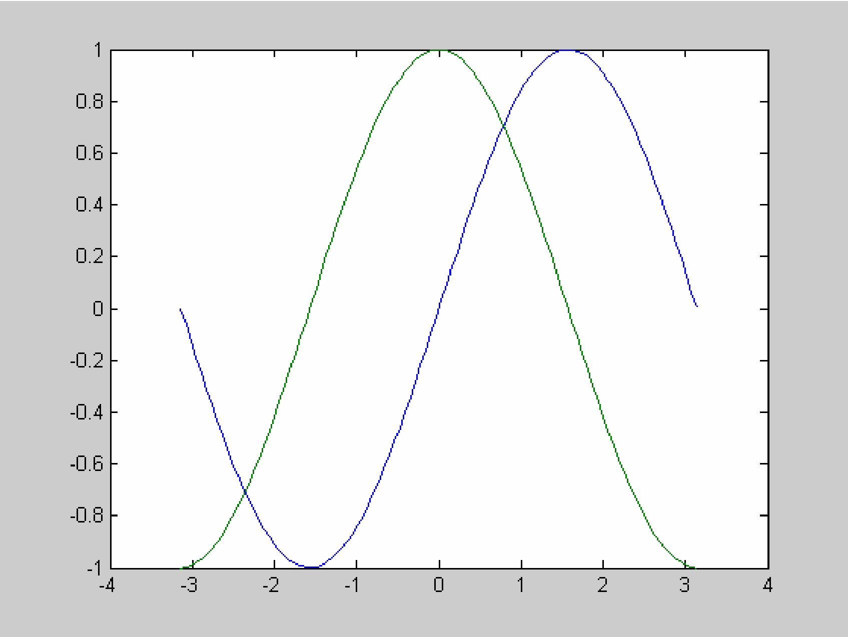


Data Files

- The data can be stored in a file.
- You should load that file by typing
  - load filename.dat

Multiple plots

- x = linspace(-pi, pi, 100);
- y = sin(x);
- z = cos(x);
- To plot both of these functions on the same graph type:
- plot(x, y, x, z);
- A new figure should pop up that looks like the following:



Logarithmic axis scaling

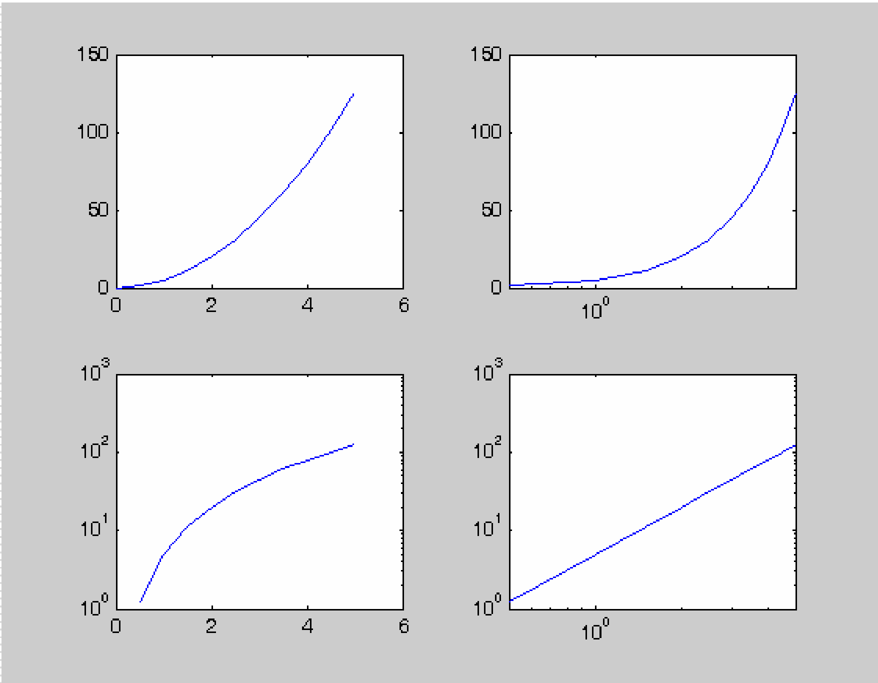
Command Name	Plot type
plot(x,y)	linear y vs linear x
loglog(x,y)	log(y) versus log(x)
semilogx(x,y)	y versus log(x)
semilogy(x,y)	log(y) versus x

Subplots

It allows you to split the graph window not subwindows.

Example:

```
x=0:0.5:5;
y=5*x.^2;
subplot (2,2,1),plot (x,y)
subplot (2,2,2),semilogx(x,y)
subplot(2,2,3),semilogy(x,y)
subplot(2,2,4),loglog(x,y)
```



EXERCISES

The balance B of a savings account after t years when a principal P is invested at an annual interest rate r and the interest is compunded n times a year is given by:

$$B = P\left(1 + \frac{r}{n}\right)^{nt}$$

If the interest is compounded yearly, the balance is given by:

$$B = P(1 + r)^{t}$$

In one account $5,000 is invested for 17 years in an account where the interest is compounded yearly.In a second account the same amount of money invested which the interest is compounded monthly. In both accounts the interest rate is 8.5%. Use Matlab to determine how long (in years and months) it would take for the balance in the second account to be same as the balance of the first

Recipe for the solution

- Calculate B for $5000 invested in a yearly compounded interest account after 17 years using Eqn 2
- Calculate the t for the B calculated in the first part from the monthly compounded interest formula, Eqn1
- Determine the number of years and months that correspond to t