EEE 208 – Programming for EEE

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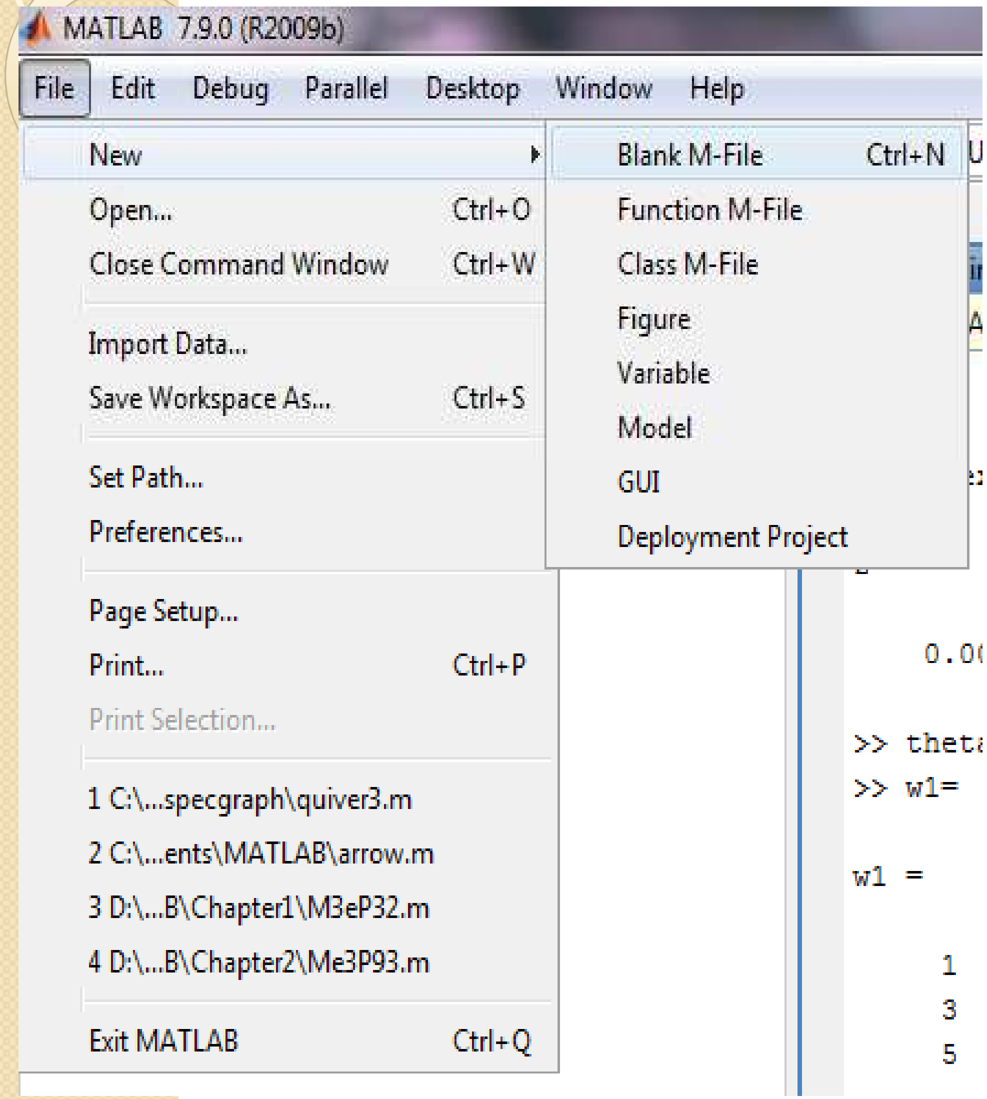
MATLAB Scripts: M-files



- Used for writing and saving scripts
- Makes it easier to edit and run programs later instead of writing long codes again and again
- Can add comments to them to make the code <u>more readable</u>

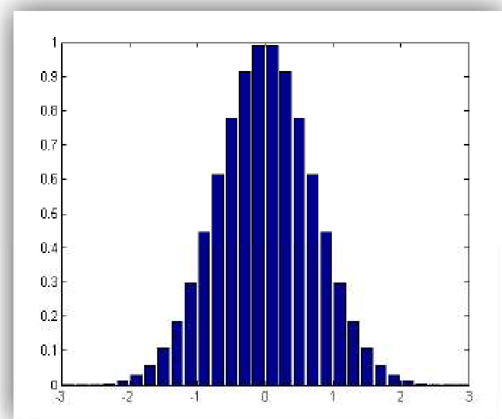
M-Files – Example

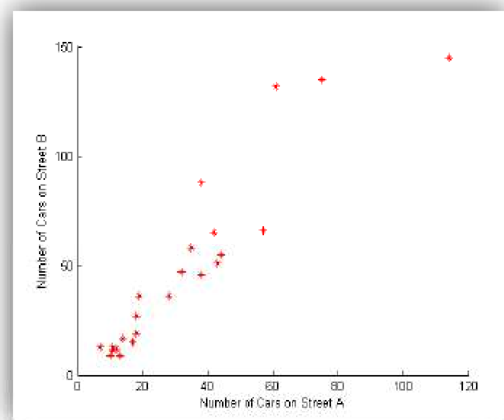
Editor - G:\dersler\programming for eee\week 2\exercise 1.m

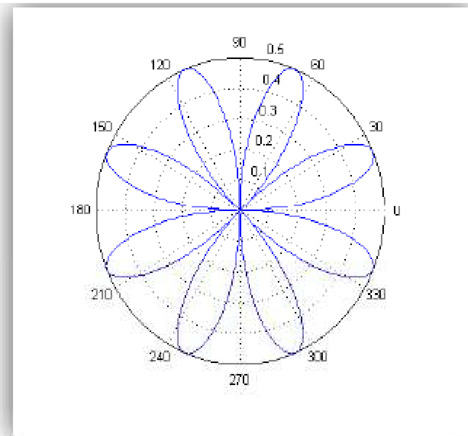
```
% Problem Stetement:
% An object has a mass of 50 kg. Find its weight a) at the equator
%(distance from the center of earth = 6,378 km), and (b) 700 meters above
% the equator.
% Gravitational constant G = 6.674 * 10^(-11) N . (m/kg)2
% Earth mass = 5.97*10^24 kg

clc
clear
close all

m_earth = 5.97* 10^24;   % Earth mass, kg
G = 6.674 * 10^(-11);    % Gravitational constant, N . (m/kg)^2
m_object = 50;           % object's mass, kg
radius = 6378* 10^3;     % earth radius, m
height = 700;            % height from the earth surface, m

% Part a: the weight on the earth surface at the equator in N
w_eq = G * m_earth * m_object / (radius^2)

% Part b: the weight 700 meters above the equator in N
w_he = G * m_earth * m_object / ((radius+height)^2)

```

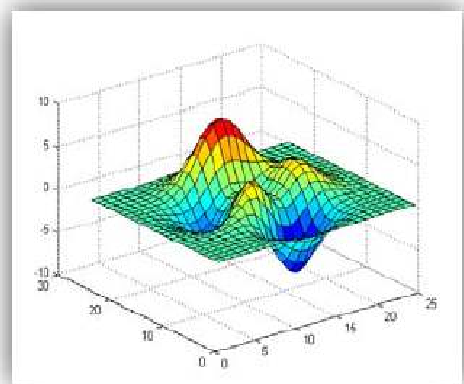
Visualization: Plotting Variables

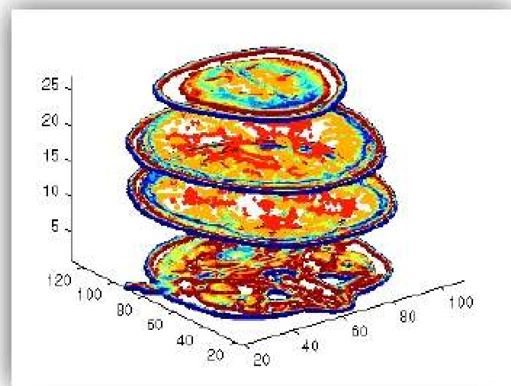
- 2D plots (x-y, loglog, semilog, scatter, bar, polar)

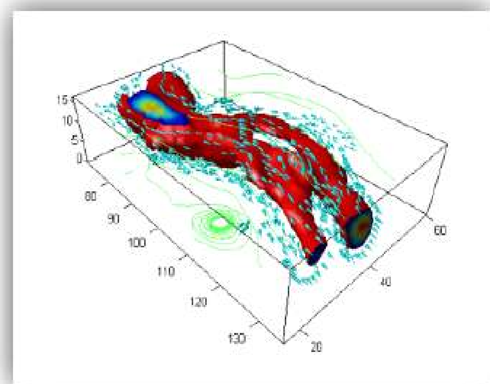












Introduction to 2D Plots - example_plot1.m

- `x=0:0.01:7;`
- `y=3*cos(2*x);`
- `z= 0.01*exp(x).*sin(1.5*x);`
- `plot` accepts 1, 2 or more input arguments
- `plot(x)` draws array x versus its number of elements
- `plot(x,y)` draws y versus x
- `plot(x,y,x,z)` draws 2 curves: y versus x and z versus y
- `subplot(rows,columns,location)`
- Type `help plot` to see more options.

2D Plots – Adding Details and Annotation

- `>> grid on`
- `>> grid off`
- `>> grid` switches between these states
- `>> xlabel('The vector x')` or `xlabel('Angle (radians)');`
- `>> ylabel('The cos series y')` or `ylabel('Amplitude');`
- `>> title('plot of z versus x');`
- `>> hold on` keeps the old plot; useful for plotting more than one curve
- `>> figure(2)`, etc is used for setting the number of plots

2D Plots – Adding colors and line styles

- The default line color is blue
- Line style comes before color
- `plot(x,y,'g')`
- `plot(x,y,'-r')`
- `plot(x,y,'-.b', x, z,'-c')`

Specifier	Line Style
`-`	Solid line (default)
`--`	Dashed line
`:`	Dotted line
`-.`	Dash-dot line

Specifier	Color
`r`	Red
`g`	Green
`b`	Blue
`c`	Cyan
`m`	Magenta
`y`	Yellow
`k`	Black
`w`	White

2D Plots – Adding marker types

- `plot(x,y,'-.+b', x, z,'-oc')`

To Close figures:

- `close`
- `close([1 2])`
- `close all`

Specifier	Marker Type
+	Plus sign
o	Circle
*	Asterisk
.	Point (see note below)
x	Cross
'square' or s	Square
'diamond' or d	Diamond
^	Upward-pointing triangle
v	Downward-pointing triangle
>	Right-pointing triangle
<	Left-pointing triangle
'pentagram' or p	Five-pointed star (pentagram)
'hexagram' or h	Six-pointed star (hexagram)

Finding Length of Vectors

- `length` returns an integer showing the number of elements in a vector
- `t1= 0:0.5:2.5;`
- `t2= 0:1/7:1;`
- `t3= 9:-2:-3;`
- `>> length(t1)`
- `>> length(t2)`

Compare:

```
>> if (length(t1) <= length(t2))
t3=t3+1;
end
```

Finding Magnitude of Vectors

- If x=[x1,x2,…,xn], then

$$\|\vec{x}\| = \sqrt{x_1^2 + x_2^2 + \cdots + x_n^2}$$

- Linear algebra: $\|\vec{x}\| = \sqrt{\vec{x} \cdot \vec{x}^T}$
- Example: x=[3,1,-2] then

mag_x=sqrt(3^2+1^2+(-2)^2)

$$\|\vec{x}\| = \sqrt{9+1+4} = \sqrt{14}$$

Creating Row Vectors with linspace

- `Linspace` creates a <u>linearly</u> spaced row vector
- `linspace(x1,x2,n)`: `x1` and `x2` are the lower and upper limits and `n` is the number of points

- Instead of specifying the step size, this command specifies <u>the number of points</u>
- `>> y=linspace(2,5,31)` is equivalent to `y=2:0.1:5`
- `linspace(x1,x2)` generates a row vector of 100 linearly equally spaced points between x1 and x2

Creating Row Vectors with logspace

- `Logspace` creates an array of <u>logarithmically</u> spaced elements.

- `logspace(a,b,n):n` is the number of points between 10^a and 10^b
- `>>x = logspace(-2,0,6)` is equivalent to vector `x = [0.0100, 0.0251, 0.0631, 0.1585, 0.3981, 1.0000].`
- `logspace(a,b)` creates a row vector with 50 points between 10^a and 10^b .

Size of Vectors

- `size` returns a vector showing the number of rows and columns
- `t1= 0:0.5:2.5;`
- `t2= 1:0.3:2;`
- `>> size(t1)`
- `>> size(t2)`
- Compare: `size(t1) < size(t2)`
- `>> size(ans)`

Vector and Matrix Operations

- If `v` is a vector and `b` a scalar, we can apply the following rules
  - Addition/subtraction by a scalar: `w=v+b`
  - Multiplication/division by a scalar: `w=b*v; w=v/b;`
- If `a` and `b` are two scalars and x and y are two vectors of the same size, then the following operations are possible:
  - `v + w`
  - `v – w`
  - `a*v + b*w`
- The same rules apply for matrices

Element-by-element Operations

- Element-by-element operations `.+, .-, .*, ./, .\`
  - Scalar division by a vector: `w=b./v;`
  - Back division by a scalar: `w=b.\v;`

- Element-by-element multiplication (<u>only</u> for arrays having <u>the same size</u>). If x and y each have *n* elements, then their product x.*y is defined as
- x.*y = [x(1)y(1), x(2)y(2), … , x(n)y(n)]

Here x and y are row vectors.

Element-by-element Operations - Examples

Symbol	Operation	Form	Examples
+	Scalar-array addition	A + b	[7,2]+3=[10,5]
-	Scalar-array subtraction	A - b	[12,3]-4=[8,-1]
+	Array addition	A + B	[6,9]+[3,7]=[9,16]
-	Array subtraction	A - B	[6,9]-[3,7]=[3,2]
.*	Array multiplication	A.*B	[7,2].*[3,6]=[21,12]
./	Array right division	A./B	[7,2]./[3,6]=[7/3,2/6]
.\	Array left division	A.\B	[7,2].\[3,6]=[7\3,2\6]
.^	Array exponentiation	A.^B	[3,9].^2=[3^2,9^2]
			2.^[3,9]=[2^3,2^9]
			[3,9].^[2,4]=[3^2,9^4]

Examples

1. `u1 = [3, -4, 2]` and `u2 = [-6, 5, 3]`

`>>u3 = u1.*u2` returns `u3 = [-18, -20, 6]`

because u3 = [3(−6), −4(5), 2(−10)]

2. Which ones are wrong and why?
`u1*u1, u1.*u1, u1^2, u1.^2`?

Examples, cont.

3. Assume we have two row vectors

```
x=0:0.1:pi;
y=linspace(0,2,length(x));
```

- Compute z = $(e^y \sin x) \cos^2 x$
- Explain what each command does.
- Which syntax returns the correct answer?

- `plot(x,y); hold on;`
- `plot(x,z)`

Example

1. Clear the workspace
2. Open the file `annual_temps.mat`
3. Double click on its matrices. What kind of information do they hold?
4. Open the file `TempAnalysis.m`
5. Discuss the operations in each section (cell).
6. Run this m-file and study the outputs.

Class Exercise 1

Problem: Find the angle (in degrees) between two vectors x=[-2, 1, 3] and y=[4, -2, 5].

1. Clear the workspace and open a new m-file.
2. Define the vectors x and y.
3. Think of the right formula from your linear algebra class.
4. Use separate variables and meaningful names for parameters.
5. Calculate the angle in degrees.

Class Exercise 2

The repulsive coulomb force between two charges is given as

$$F = \frac{q_1 * q_2}{4\pi\varepsilon_0 r^2}$$

If $q_1 = 1.6 * 10^{-19} C$ and $q_2 = 3.2 * 10^{-19} C$ and $\frac{1}{4\pi\varepsilon_0} = 8.99 * 10^9 \, Nm^2/C^2$, sketch a graph of force versus radius r. Assume a radius from $1.0 * 10^{-14} m$ to $0.5 * 10^{-13} m$ with increments of $2.0 * 10^{-15}\, m$.

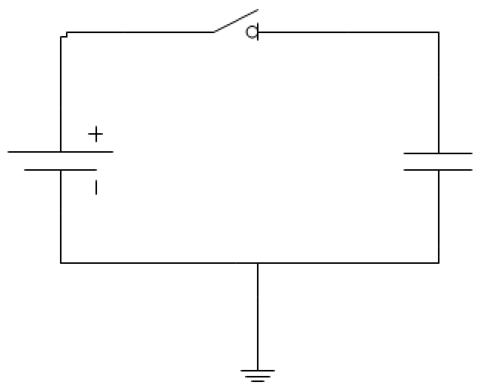
Class Exercise 2, Instructions

1. Clear the workspace and open a new m-file.
2. Define parameters for the distance, constants, and charge values. What is the size of r?
3. Calculate the force F using the above formula.
4. Plot the force F versus r

Class Exercise 3

Problem: The voltage across a charging capacitor is $v(t) = 10(1 - e^{-0.2t})$.

Calculate the capacitor's voltage, $v(t)$, versus time, t, for $t = 0$ to 40 seconds with step size of 0.5 seconds. Then plot $v(t)$ versus time using black solid lines and star markers.



Class Exercise 4

Problem: The voltage in a simple resistor circuit increases from 0 to 8V in steps of 2V. Find the current passing through the 10 kΩ resistor.

Calculate the power that turned to heat in that resistor and plot it.