Applied Analysis Lab - CET 3625

New York City College of Technology
Dept. of Comp. Eng. Technology
Fall 2019
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CET 3625 Course Description

- Application of calculus and differential equations to modeling and problem solving utilizing scientific software (Matlab)
- Co-requisite MAT2680 (Differential Equations)
- Learning Outcomes:
  - Analyze circuits and compare mathematical, simulated and practical solutions
  - Develop programs for scientific applications
  - Understand use of applied mathematics such as integration, diff. equations, fourier and laplace transformations in engineering and technology

Grading

- Midterm Exam 20%
- Final Exam 25%
- Laboratory Reports 15%
- Class Note Submission 15%
- Project 25%
- Total 100%

Class Schedule (subject to change)

- Week 1+2
  - Introduction, Complex Numbers, Functions
  - Plotting
  - Lab 1: Plotting of simple circuit
- Week 3+4
  - Matrix algebra, system of equations
  - Lab 2: Mesh circuit analysis
- Week 5+6
  - Fourier series
  - Lab 3: Application of fourier series
- Week 6 - Midterm Exam

Class schedule cont.

- Week 9-11
  - Ordinary Differential Equations (ODE)
  - Application to RC, RL circuits
  - Applications to RCL circuits
  - Lab 4: Circuit simulation
- Week 12-14
  - Laplace Transforms
- Week 15
  - Final Exam & Final Project due
  - Final Project Presentations

Introduction

- Please prepare a name tag
  - Prepare a seating chart
- Lets quickly introduces ourself
  - Whats your major?
  - What year are you in?
  - Your experience with programming
    - Matlab, Python, Julia, C++, Java, JavaScript etc
  - Special interests, what do you hope to get out of this class?

Install Matlab

- Install virtual desktop
  - http://cuny.edu/virtualdesktop
  - Log in with your CUNYFirst UID and PW
- Alternative: install on personal computer
  - Create Math Works Account using your university email address:
    - mathworks.com/accesslogin/createProfile.do
    - Choose Associate License at mathworks.com/licensecenter

Install Matlab cont

- Enter Activation Key:
  - 14317-60551-55097-39870-91449
- Download current release from
  - mathworks.com/downloads/web_downloads/select_release
- Run the installer and log in with your MathWorks account

Introduction to Matlab

- High level programming language
- Large number of build in functions
- Plotting and visualization tools
- Specialized toolboxes (Simulink)
- Large number of documentation and resources
- Large usage base in academics and engineering
- Alternatives: scilab, octave, python, sage, julia

Command line

- Basic operations with variables

  >>a = 5

  >>b = 6

  >>a+b

  ans = 11

- Creating arrays

  >>a = [1 2 3 4 5]

  >>power(a,2)

  ans = 1 4 9 16 25

Live Script

- Live scripts allow to mix ‘Text’ and ‘Code’
- Use ‘Output inline’ option toggle
- For each class create a live script to record your work and take notes
- Submit labs and class notes as live script documents

Complex numbers

- Imaginary unit i (can also use j)

```
>>z=5+6j
>>z=complex(5,6)
ans = 5+6i
```

- Complex conjugate

```
>>conj(z)
ans = 5-6i
```

- Real and imaginary parts

```
>>a=real(z); b=imag(z)
```

Polar representation

- Complex number in polar coordinates
  $\Rightarrow$z=r*cos(theta)+ j*r*sin(theta)

- Euler formula
  $\Rightarrow$z = r*exp(j*theta)

```
>>z=5+6j
>>theta = angle(z)
>>r = abs(z)
>>r*exp(j*theta)
>>ans = 5+6i
```

Operations with complex numbers

- Multiplication adds phases
- Division subtracts phases

Try:

```
>>z1 = 2*exp(j*(2*pi)*30/360)
>>z2 = 3*exp(j*(2*pi)*45/360)

>>angle(z1*z2)*360/(2*pi)
>>angle(z1/z2)*360/(2*pi)
>>abs(z1*z2)
>>abs(z1/z2)
```

What do you get?

Application: Impedance Z=V/I

- Resistor Zr = R
- Inductor Zl = j*w*L
- Capacitor Zc = 1/(j*w*C)

- Total Impedance for RCL circuit in series
  $\Rightarrow$Z=Zr+Zl+Zc
  $\Rightarrow$see next slide for example values

RCL impedance

- Impedance allows to calculate the phase shift angle(Z) between driving voltage(AC) Vt=V0*sin(wt) and resulting current.
  $\Rightarrow$(see RCL circuit project slide)
- V0 = 25
- w = 50*2*pi
- R = 50
- L = 0.3
- C = 15E-6

Function plotting and graphs

- Create array of values to be evaluated

>>t = 0:0.25:1

>>t = linspace(0,1,5)

ans = 0 0.25 0.5 0.75 1

- Evaluate function for each array value

>>sin(t)

ans = 0 0.24 0.47 0.68 0.84

BUT, trying t^2 gives an error, why?

Anonymous Functions

- Special symbol @ to indicate the function
- name = @(arguments) calculation

>>mysquare = @(x) x^2

>>mysquare(3)

>>ans = 9

- “arrayfun(function, array)” applies each item of an array individually to a function

>>arrayfun(mysquare , [1 2 3 4])

>>ans = 1 4 9 16

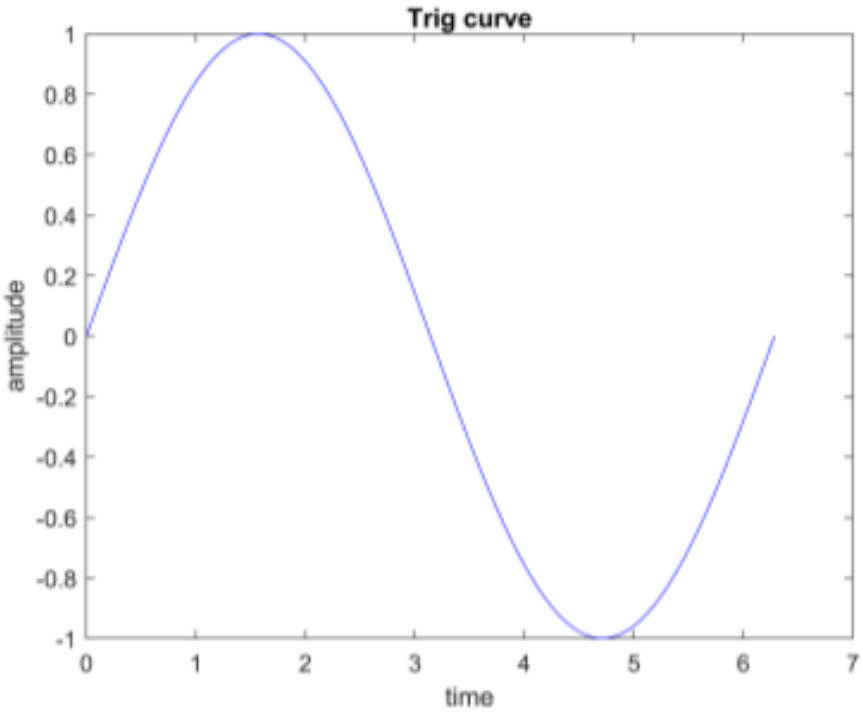
Plotting

- Use plot(x,y,'format') to create simple graphs

```
t=linspace(0,2*pi,100);
y=sin(t);
figure;
plot(t,y,'b-')
title('Trig curves')
xlabel('time')
ylabel('amplitude')
```

Plotting Live Script Example

```
t=linspace(0,2*pi,100);
y=sin(t);
figure;
plot(t,y,'b-')
title('Trig curve')
xlabel('time')
ylabel('amplitude')
```



Overlay multiple graphs

- use ”hold” to prevent erasing

```
>>hold on
>>u=cos(t);
>>plot(t,u,’g-‘)
>>xline(pi/4,’r-‘)
```

- What value X should we use to use axis to mark the next time where sin and cos cross?

```
>>xline(X, ‘r-‘)
>>legend('sin','cos','1st cross', '2nd cross')
>>hold off
```

Plot vertical line with xline

- The matlab function to generate a vertical line is xline(xposition, formatstring)
- The function xline only works for matlab versions 2018 and later
- For older matlab versions, define xline as:

  $\Rightarrow$xline = @(x,str) plot([x x], get(gca,'ylim'),str)

RLC circuit project

- Uses previous values for RLC circuit to plot AC current and voltage vs time
- Vt = V0*sin(wt)
- It = I0*sin(wt - delta)
- Vt/It = Z

- Use the magnitude (abs) and phase (angle) of the impedance to calculate the amplitude I0 of the current and the phase shift delta.

Frequency response

- Plot the amplitude of AC current I0 vs a range of the driving frequency f, with w=2*pi*f.
- Add a vertical line to mark the resonance frequency where the current peaks.

- Hint: define an anonymous function that returns I0=V0/abs(Z) for a given frequency f