Signals and Systems EEE202

MATLAB Project

Spring 2024/2025

Introduction:

1. Start working on the different parts of the project as more parts will be added on gradually.
2. Do not submit until all parts are completed.
3. Submission will be into BlackBoard through SafeAsign and STRICTLY NO Email submission will be accepted!
4. The submitted file should be a single pdf file.
5. In the file, each Task will comprise two parts. The first is the code you wrote, and the second its output including all figures, etc. This will be saved into a pdf file and submitted.
6. The submitted file name should contain the student's name and ID, e.g. Burak Tekin_20309012345.

Objectives:

Various elements of MATLAB are expected to be learned by the student and included into the project elements. The more important are listed here, but students may use other elements. Generally, the student is expected how to create and manipulate data elements (such as arrays, images, etc.), process them, and present them in different formats of plots and charts. Also needed is "".m" files" and functions.

Functions:

Pi, sin, cos, asign, acos, i, j, abs, conj, angle, inf, eps, NaN, realmax, realmin, log, sqrt, sign, ceil, floor, round, fix, factorial, linespace, figure, plot, stem, subplot, loglog, semilog, semiology, area, polar, clear, clc, length, size, sum, cumsum, max, min, mean, median, sort, ones, zeros, rand, randn, eye, display, num2str. All mathematical/logical/relational operations required to set up and analyse matrices, e.g. diag, inv, etc. Syntax to control the flow of code execution is also needed such as if, while, switch, while, break, etc. is important. Finally, symbolic calculation will be introduced that includes differentiation, integration, and perhaps solving differential equations.

Tasks:

Q.1. 13 April 2025

A. Generate a row vector of 1000 equally spaced points between 0 and 2π.
B. Plot on the same figure in the interval [0 2π] the functions $f(x) = xe^{-x}, 0 \leq x \leq 2\pi$ and $f(x) = e^{\cos(x)}, 0 \leq x \leq 2\pi$.
C. Add a title (of your choice) to the graph.
D. Label the two axis of the graph.
E. Insert a legend for all functions that appear in the graph.
F. Plot the above functions at a second figure in two different subfigures.

Q.2. **26 April 2025**

A. Generate a row vector of around 200 equally spaced points between -1.6 and 1.6. This should represent time.
B. Generate the periodic square pulse function given by $x(t) = 1.0\ for\ |t| < 0.2$ and $x(t) = 0.0\ for\ 0.2 < |t| < 0.5$ similar to example 3.5 in the book. Notice the period T is chosen to be 1.0 and as in the book $\omega_0 = 2\pi/T$.
C. Using the Fourier coefficients (a_k) given in the book, generate the sinusoidal waves according to the relevant harmonics (i.e. $\omega_k = k * w_0$). You can use the excel file uploaded into BB for assistance.
D. Generate the sum of harmonic sinusoids, e.g. d.c. value + 1st harmonic sinusoid, d.c. value + 1st harmonic sinusoid+ 2nd harmonic sinusoid, etc. up to and including the 7th harmonic function.
E. Generate the error (i.e. the difference between the original function $x(t)$ and the simulated function from the harmonic functions.
F. Plot all above mentioned functions into one figure with two columns of curves, including the error functions.
G. Calculate a measure of average error (i.e. over one period) from which to determine how many harmonics need to be added together in order to have an average error of less than 5% between $x(t)$ and the synthesized function.

Q.3. **26 May 04**

A. Generate a row vector “t” of 1001 equally spaced points between 0.0 and 1.0. This should represent time. How many elements are in this vector (Call this value “N1”).
B. Generate a sinusoidal wave vector “x1” of amplitude 1.0 and frequency $\omega 0 = 2\pi$, using the above vector “t” as the independent variable.
C. Calculate the autocorrelation “x11” vector of “x1” with itself. Generate “x11” versus a new independent variable vector “t2” of the same step size as in “A” above. What should the lower & upper limits of this “t2” vector be?
D. Generate another sinusoidal wave vector “x2” of amplitude 1.0 and frequency 10 $\omega 0$, using the above “t” vector as the independent variable. Generate “x22” as in “C” above, i.e. autocorrelation of “x2” with itself.
E. Generate a vector “x3” of “N1” elements. The values should be randomly generated with amplitudes between -1.0 and +1.0. Generate “x33” as in “C” above, i.e. autocorrelation of “x3” with itself.
F. Generate a vector “x4” which is the sum of “x1” and “x3”. Generate “x44” autocorrelation of “x4” with itself.
G. Generate a vector “x5” which is the sum of “x1” and “2*x3”. Generate “x55” autocorrelation of “x5” with itself.
H. Generate a vector “x6” which is the sum of “x1” and “10*x3”. Generate “x66” autocorrelation of “x6” with itself.
I. Plot all the above functions in the same figure, of two columns and six rows.
J. Comment on each result obtained and compare the different curves.

Q.4. **26 May 13 – Linearity of Fourier Transform**

A. Generate a row vector “t” of 256 equally spaced points (step of 1 unit) between -127 and 128. This should represent time vector.
B. Generate a decaying exponential function “x1” of amplitude A1=3 and time constant C=10. To make the function symmetric, use the absolute value of “t” as the independent variable (x1=A1*exp(-abs(t)/C). Notice MATLAB requires positive vector indices. See the example given about the sinc(t) function.

C. Generate a "sinc(t)" function which is a sinusoidal wave vector divided by "t". Call it "x2" of amplitude A2=12 and frequency $\omega 0 = 2\pi/16$, using the above vector "t" as the independent variable. Notice MATLAB requires positive vector indices.
D. The sinc(t) function will have a discontinuity (NaN) at t=0. You need to set this manually x2(N)=A2*w0.
E. Generate the Fourier Transform of x1 by using the function "fft". Apply <u>frequency centring</u> by using the function "<u>fftshift</u>". Call this function x1FT.
F. Repeat E above for x2 and call it x2FT.
G. Generate a new function "x3" by adding the two functions "x1"and "x2".
H. Generate the Fourier Transform of x3 in a similar manner to E and F above. Call this x3FT.
I. Generate the sum of x1FT and x2FT. Call this x12FTsum.
J. Generate the difference between x3FT and x12FTsum. Call this x12FTdif.
K. Generate 14 subplots in 1 figure according to:
    1. x1.
    2. the phase angle of x1FT (use the function angle(x1FT).
    3. x2.
    4. the phase angle of x2FT (use the function angle(x2FT).
    5. the absolute value of x1FT (use the function abs(x1FT).
    6. the absolute value of x2FT (use the function abs(x2FT).
    7. the real value of x1FT.
    8. the real value of x2FT.
    9. the imaginary value of x1FT.
    10. the imaginary value of x2FT.
    11. the absolute value of x3FT.
    12. the absolute value of x12FTsum.
    13. the absolute value of x12FTdif.
    14. the phase angle value of x12FTdif.

This MATLAB exercise is meant to demonstrate some of the properties of FT such as Linearity. Comment on FT pairs, e.g. the sinc(t) function and its FT. Also comment on the various components of FT such as real, imaginary, etc. Finally, can you demonstrate the linearity property of FT!