UNIVERSITY OF THE PHILIPPINES DILIMAN
ELECTRICAL AND ELECTRONICS ENGINEERING INSTITUTE

EE 274 / COE 197E: Discrete Time Signals & Systems (DSP1)
Programming Exercise 02
DEADLINE: 11-OCT-2020

INSTRUCTIONS. This is an open-notes, open-books exercise, and can be done solo or by pair (For those under EE 274, you are required to do this individually). Write your name/s and student number/s on the topmost part of the lab report. The exercises are designed to be done in MATLAB or Octave. For convenience, use the **Publish** to **DOC/PDF** feature of MATLAB. Comment your answers to the questions.

Submit copies of your well-commented codes and automatically generated lab report in a compressed folder via UVLE no later than the designated deadline. Use the filename EE274_ProgEx02.zip or CoE197E_ProgEx02.zip. Anything submitted beyond the deadline will get a 0.6 multiplier penalty to the final score.

A. DIFFERENCE EQUATIONS IN MATLAB

Discrete time systems can be represented using block diagrams and difference equation. Shown below is an example of a discrete time ARMA system:

$$y[n] = x[n] + 5x[n-1] + 2y[n-1]$$

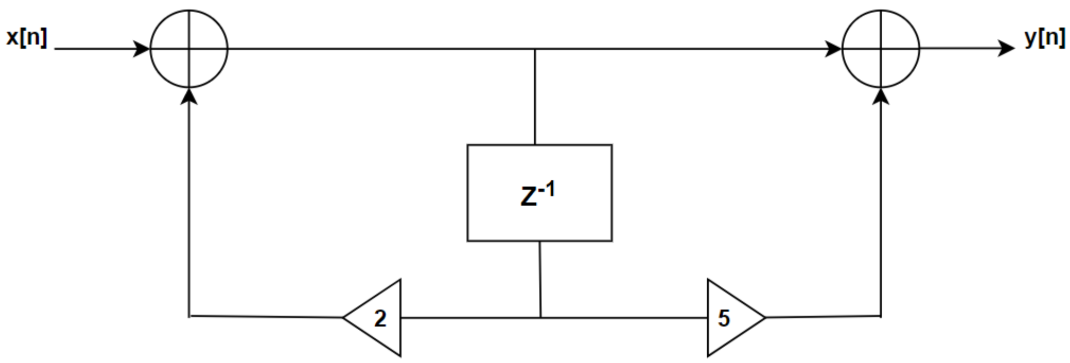

Figure 1. Direct Form II representation of the system

In MATLAB, we usually use the following vectors to represent a discrete time system:

$$a_0 y[n] + a_1 y[n-1] + \cdots + a_N y[n-N] = b_0 x[n] + b_1 x[n-1] + \cdots + b_M x[n-M]$$

$$b = [b_0\ b_1\ b_2\ ,,,b_M] \rightarrow \textbf{coefficients of the input}$$

$$a = [a_0\ a_1\ a_2\ ,,,a_N] \rightarrow \textbf{coefficients of the output}$$

In the given example, we have:

```
b = [1 5]

a = [1 -2]
```

B. SYSTEM RESPONSE CALCULATION

a. Using recursion
We can simulate the recursion using the for loop function. For the code below, the simulation runs on the entire domain of n:

$$\boldsymbol{y[n] = x[n] + 5x[n-1] + 2y[n-1]}$$

```
x = randn(1,5); %random input signal x
y = zeros(1,length(x)); %initialize output signal y
for n = 1:length(x)  %5 time indices

  if n<2
       y(n) = x(n);
  else
       y(n) = x(n) + 5*x(n-1) + 2*y(n-1);
  end
end

figure;

subplot 211
stem(1:5,x); title('input signal');

subplot 212
stem(1:5,y); title('output signal');
```

b. Using the impulse response and DT convolution
We can also simulate response using the **impz ( )** function and **conv ( );**

```
b = [1 5]; a = [1 -2];
h = impz(b,a); %impulse response
y = conv(h,x);

figure;

subplot 211
stem(1:5,x(1:5)); title('input signal');

subplot 212
stem(1:5,y(1:5)); title('output signal');
```

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C. EXERCISES

You are given the following discrete time systems:

	Difference Equation
System 1	$y[n] = 0.5x[n] + 0.5x[n-1]$
System 2	$y[n] = x[n] - 2y[n-1] - 2y[n-2]$
System 3	$y[n] = 1.5x[n] + 0.5x[n-1] - 2y[n-1] - 2y[n-2]$
System 4	$y[n] = x[n] + 0.5y[n-L] + 0.5y[n-L-1]$

For each system, determine the following using MATLAB:

1. Create a **function file** (M-file) that returns a vector **y** from a given input **x**. (Make sure the **lengths are the same** and are **using the same sampling period**). For systems 1&2, perform the recursive method. For systems 3&4, use the impulse response method. System 4, should have an extra input L. Assume zero initial conditions.

   Format: `y = dt_1(x), y = dt_2(x), y = dt_3(x), y = dt_4(x,L)`

   On a separate M- script:

2. Investigate the output response from the given input signals. Use **figure ( )** and **subplot ( )** to compare the time domain plot of x versus y. For system 4, try L = 100.

3. Compare the input and output signals by listening using **soundsc (y,fs).** For system 4, try the following values of L = 50, 100, 400.

4. Answer the following questions (Use MATLAB to support your answer):
   a. Is the system BIBO stable? (*Hint: use impz ( )*)
   b. Is the system causal?
   c. Is the system FIR or IIR?
   d. What does the system do? (Based from #2&#3, you may also use **freqz (b,a)** to have an insight on the filter / frequency response)

References:

https://www.mathworks.com/