Faculty of Computers and Artificial Intelligence
Final Exam

Department: Information Technology	
Course Name: Digital Signal Processing	Date: 27/6/2022
Course Code: IT341	Duration: 2 hours
Instructor(s): Prof. Reda Abdul-Wahab	Total Marks: 60

تعليمات هامة

- حيازة الهاتف المحمول مفتوحا داخل لجنة الامتحان تعد حالة غش. إذا كان ضروريا الدخول بالمحمول فيوضع مغلقا فى الحقائب.
- لا يسمح بدخول سماعة الأذن أو البلوتوث.
- لا يسمح بدخول أي كتب او ملازم او اوراق داخل اللجنة والمخالفة تعتبر حالة غش.

ATTEMPT ALL QUESTIONS

Question 1: **[15 Points]**

[a] Determine the properties of each of the following discrete time systems (linearity, causality, memory, time invariance, stability

$$y[n] = x[2n] + 2$$

$$y[n] = x[n-2]\cos\omega_0 n$$

[b] The non-zero values of a discrete-time signal are given as $x[0] = 2 + 2j$ and $x[1] = 1$. Decompose x[n] into conjugate symmetric (even) and conjugate anti-symmetric (odd) signals.

[c] If a continuous- time sinusoidal signal of frequency is 131 Hz is sampled at a sampling rate of 8000 Hz. What is the discrete-time frequency in rad/sample of the resulting discrete-time signal?

[d] Find the linear and 4-point circular convolutions between x[n] and h[n] given that:

$$x[n] = [\underline{1}, 0, 2, 3]$$

$$h[n] = [\underline{2}, 1, 4]$$

[e] Draw the butterfly diagram used to evaluate the 4-point FFT of the signal $x[n] = \delta[n] + 2\delta[n-1] + \delta[n-2]$.

[f] Determine the z-transform (if it exists) and the corresponding ROC. Also determine the DTFT (if it exists) for the signal:

$$x[n] = 2^n u[-n-2] + 0.5^n u[n-1]$$

Question 2: **[15 Points]**

a) Find the impulse response of the following filter assuming it is a causal filter:

$$H(z) = \frac{1 - (\cos\omega_0)z^{-1}}{1 - (2\cos\omega_0)z^{-1} + z^{-2}}$$

b) For a signal with transfer function given by:

$$X(z) = \frac{2z^{-1} + 3}{1 - 0.3z^{-1} + 0.03z^{-2}}$$

Find all the possible ROC's and the corresponding time domain representation of the signal. Which signal has a defined DTFT?

c) Consider a digital filter where the z-transform of the impulse response is

$$H(z) = \frac{z^2 - 1}{z^2 + \frac{49}{64}}$$

Plot the poles and zeros of the filter. Find the ROC of the stable realization of the filter. Sketch the frequency response and determine the type of the filter

Question 3: **[15 Points]**

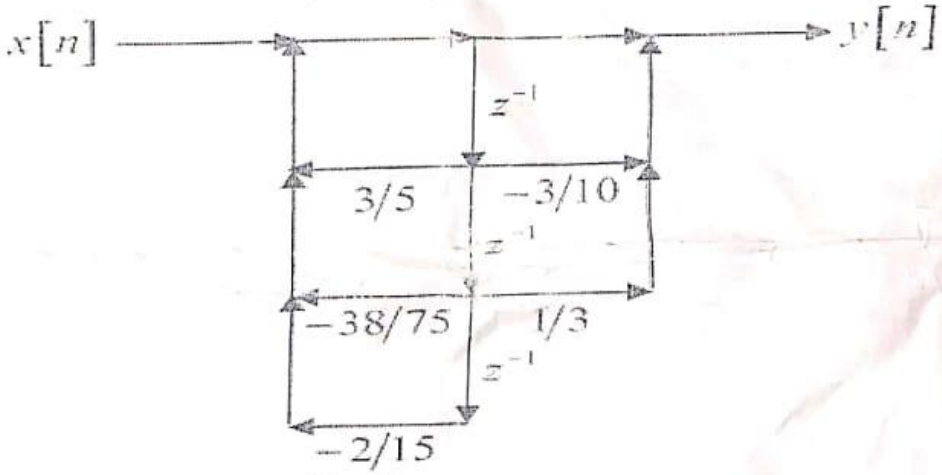
a) A discrete-time system is given as

$$y[n] = ay[n-1] + x[n] - ax[n-1],$$

where a is a real scalar constant. Find:

i) The impulse response of the system.
ii) The range of values of a for which the system is BIBO stable.

b) Consider the filter defined by the following block diagram:



Write the transfer function of the filter.

c) Draw a realization for the following system using the canonical direct form II and parallel form:

$$H(z) = \frac{1 - 2z^2}{1 - 1.2z^{-1} + 0.32z^{-2}}$$

[15 Points]

Question 4:

a) For the following analog filter:

$$H(s) = \frac{10(s+1)}{s^2 - 6s + 10}$$

Find the transfer function of the corresponding digital filter using impulse invariance method with sampling period $T_s = 0.001\ s$

b) Write the transfer function of the second order digital Butterworth filter with normalized cutoff frequency $\omega_c = 0.4\pi\ rad$ if bilinear transformation is used to convert the analog filter to digital and assuming T=1 sec.