40. Course Specification of Digital Signal Processing

<table>
<tr><th colspan="7">I. Course Identification and General Information:</th></tr>
<tr><td>1.</td><td>Course Title:</td><td colspan="5">Digital Signal Processing</td></tr>
<tr><td>2.</td><td>Course Code & Number:</td><td colspan="5">CNE317</td></tr>
<tr><td rowspan="3">3.</td><td rowspan="3">Credit hours:</td><td colspan="4">C.H.</td><td rowspan="2">Total C.H.</td></tr>
<tr><td>Th.</td><td>Tu.</td><td>Pr.</td><td>Tr.</td></tr>
<tr><td>2</td><td>2</td><td>2</td><td>-</td><td>4</td></tr>
<tr><td>4.</td><td>Study level/ semester at which this course is offered:</td><td colspan="5">4^{th} Level/ 1^{st} Semester</td></tr>
<tr><td>5.</td><td>Pre –requisite (if any):</td><td colspan="5">Signals and Systems (CNE216), Communications Principles (CNE2211), Programming Language 2 (C/C++) (CCE152) Matlab.</td></tr>
<tr><td>6.</td><td>Co –requisite (if any):</td><td colspan="5">None</td></tr>
<tr><td>7.</td><td>Program (s) in which the course is offered:</td><td colspan="5">Communication and Network Engineering</td></tr>
<tr><td>8.</td><td>Language of teaching the course:</td><td colspan="5">English</td></tr>
<tr><td>9.</td><td>Location of teaching the course:</td><td colspan="5">Faculty of Engineering, Sana’a University</td></tr>
<tr><td>10.</td><td>Prepared By:</td><td colspan="5">Assoc. Prof. Dr. Mohammed A. Saeed Al-Mekhlafi</td></tr>
<tr><td>11.</td><td>Date of Approval</td><td colspan="5">2020</td></tr>
</table>

II. Course Description:

This course introduces the basic concepts and principles of Digital Signal Processing (DSP) and their applications. Topics include: Review of discrete-time (DT) signals and systems; Correlation, convolution, sampling theorem, aliasing, and quantization, frequency-domain representation of discrete-time signals and systems, circular convolution, decimation and interpolation, the discrete-time Fourier transform (DTFT), the discrete Fourier transform (DFT), the fast Fourier transform (FFT), the z-transform, linear phase transfer functions, digital filter structures, finite-impulse response (FIR) digital filter design, infinite-impulse

response (IIR) digital filter design, digital processing of continuous-time signals, and applications of digital signal processing in communications.

	III. Course Intended learning outcomes (CILOs) of the course	Referenced PILOs
a1	Demonstrate the basic signal processing techniques and algorithms and ability to apply them in signal processing and system analysis.	A1
a2	Define the periodic sampling of continuous signals and the relationship between Fourier transforms of the sampled continuous signal and the resulting discrete-time signal.	A1, A2
b1	Analyze the impulse- and frequency-response of a discrete LTI system by using DSP tools such as z-transform and DFT techniques.	B2
b2	Analyze discrete-time signals in time and transform domains, using tools such as FFT and inverse FFT.	B3
c1	Implement different types of digital filters to meet arbitrary specifications.	C2
c2	Use computers and MATLAB to create, analyze, and process signals, and to simulate and analyze systems.	C4
d1	Write signal processing algorithms and methods with minimal supervision and communicate the outcomes as a written report.	D4

(A) Alignment Course Intended Learning Outcomes of Knowledge and Understanding to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1 – Demonstrate understanding of the basic signal processing techniques and algorithms and ability to apply them in signal processing and system analysis.	▪ Interactive Lectures ▪ Class Discussions ▪ Problem Solving ▪ Independent readings	▪ Assignments ▪ Quizzes ▪ Midterm Exam ▪ Final Exam
a2 – Define the periodic sampling of continuous signals and the relationship between Fourier transforms of	▪ Interactive Lectures ▪ Class Discussions	▪ Assignments ▪ Quizzes ▪ Midterm Exam

the sampled continuous signal and the resulting discrete-time signal.	▪ Problem Solving ▪ Independent readings	▪ Final Exam

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1 – Analyze the impulse- and frequency- response of a discrete LTI system by using DSP tools such as z-transform and DFT techniques.	▪ Interactive Lectures ▪ Class Discussions ▪ Problem Solving ▪ Independent readings	▪ Assignments ▪ Quizzes ▪ Midterm Exam ▪ Final Exam
b2 – Analyze discrete-time signals in time and transform domains, using tools such as FFT and inverse FFT.	▪ Interactive Lectures ▪ Class Discussions ▪ Problem Solving ▪ Independent readings	▪ Assignments ▪ Quizzes ▪ Midterm Exam ▪ Final Exam

(C) Alignment Course Intended Learning Outcomes of Professional and Practical Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
c1 – Implement different types of digital filters to meet arbitrary specifications.	▪ Interactive Lectures ▪ Class Discussions ▪ Problem Solving ▪ Matlab Simulations ▪ Independent readings	▪ Assignments ▪ Quizzes ▪ Midterm Exam ▪ Final Exam ▪ Written Reports
c2 – Use computers and MATLAB to create, analyze, and process signals, and to simulate and analyze systems.	▪ Interactive Lectures ▪ Class Discussions ▪ Computer base Learning ▪ Problem Solving ▪ Independent readings	▪ Assignments ▪ Quizzes ▪ Midterm Exam ▪ Final Exam ▪ Written Reports

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1 - Write signal processing algorithms and methods with minimal supervision and communicate the outcomes as a written report.	▪ Web-based Investigations ▪ Independent readings	▪ Written Reports

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact Hours
1.	Review of Discrete-Time Signals and Systems	a1	▪ Discrete-Time Sequences, - Discrete-Time Systems, ▪ Linear Time-Invariant Systems (LTI), ▪ Impulse Response, ▪ Convolution in Time, ▪ Properties of LTI Systems	1	2
2.	Sampling and Reconstruction	a2	▪ Periodic Sampling, the Concept of Aliasing, ▪ Quantization, ▪ Coding of ▪ Quantized Samples, ▪ Frequency-Domain ▪ Representation of Sampling, ▪ Reconstruction of Band-Limited Signals, ▪ Changing the Sampling Rate of Discrete Signals, ▪ Digital-to-Analog Conversion	2	4
3.	z-Transform and its Inverse	a1, b1	▪ The Direct z-Transform, ▪ Properties of the z-Transform,	3	6

			▪ Poles and Zeros, ▪ Pole Location and Time-Domain Behavior for Causal Signals, ▪ The System Function of a Linear Time-Invariant System, ▪ The Inverse z-Transform, ▪ Analysis of Linear Time-Invariant Systems in the z-Domain		
4.	Discrete Fourier Transform (DFT)	a1, b1, c1	▪ Understanding the DFT Equation, ▪ The DFT Properties, ▪ Inverse DFT, ▪ Zero Padding and Frequency-Domain Sampling, ▪ Interpreting the DFT Using the Discrete-Time Fourier Transform, ▪ Linear and Circular ▪ Convolution	2	4
5.	Fast Fourier Transform (FFT) and FFT analysis	a1, b2, c1	▪ Relationship of the FFT to the DFT, ▪ Hints on Using FFTs in Practice, ▪ Block Convolution, ▪ The Goertzel Algorithm, ▪ Decimation in Time and in ▪ Frequency, ▪ FFT Analysis.	2	4
6.	Basic structures of IIR- and FIR filters	a1, c1	▪ Filter Structures (direct form I & II), ▪ Signal Flow Graph Representations,	2	4

			▪ IIRSystems, ▪ Transposed Forms, ▪ FIR Systems		
7.	Design of Finite Impulse Response (FIR) Filters	a1, c2	▪ Design of FIR Filters Using the Kaiser Window, ▪ The Parks-McClellan Algorithm, ▪ Minimum Weighted Mean-Squared Error Criterion	1	2
8.	Design of Infinite Impulse Response (IIR) Filters	a1, c2	▪ Design of Butterworth ▪ Chebyshev Type I IIR Filters, ▪ Comparison of the ▪ Performance of FIR and IIR Filters	1	2
Number of Weeks /and Units Per Semester				**14**	**28**

B - Tutorial Aspect:

Order	Tutorial Skills List	Number of Weeks	C.H.	CILOs
1.	Discrete-Time Signals and Systems • Discrete-Time Sequences • Discrete-Time Systems • Linear Time-Invariant • Systems (LTI) • Impulse Response • Convolution in Time • Properties of LTI Systems	2	4	a1
2.	Sampling and Reconstruction • Periodic Sampling, the Concept of Aliasing • Quantization • Coding of Quantized Samples • Frequency-Domain Representation of Sampling	2	4	a2

	• Reconstruction of Band-Limited Signals • Changing the Sampling Rate of Discrete Signals • Digital-to-Analog Conversion			
3.	z-Transform and its Inverse • The Direct z-Transform • Properties of the z-Transform • Poles and Zeros • Pole Location and Time-Domain Behavior for Causal Signals • The System Function of a Linear Time-Invariant System • The Inverse z-Transform • Analysis of Linear Time -Invariant Systems in the z-Domain	2	4	a1, b1
4.	Discrete Fourier Transform (DFT) • Understanding the DFT Equation • The DFT Properties • Inverse DFT • Zero Padding and Frequency-Domain Sampling • Interpreting the DFT Using the Discrete-Time Fourier Transform • Linear and Circular Convolution	2	4	a1, b1, c1
5.	Fast Fourier Transform (FFT) and FFT analysis • Relationship of the FFT to the DFT • Hints on Using FFTs in Practice • Block Convolution • The Goertzel Algorithm • Decimation in Time and in Frequency • FFT Analysis	2	4	a1, b2, c1
6.	Basic structures of IIR- and FIR filters • Filter Structures (direct form I & II) • Signal Flow Graph Representations	1	2	a1, c1

	• IIRSystems • Transposed Forms • FIR Systems			
7.	Design of Finite Impulse Response (FIR) Filters • Design of FIR Filters Using the Kaiser Window • The Parks-McClellan Algorithm • Minimum Weighted Mean-Squared Error Criterion	2	4	a1, c2
8.	Design of Infinite Impulse Response (IIR) Filters • Design of Butterworth • Chebyshev Type I IIR Filters • Comparison of the Performance of FIR and IIR Filters	1	2	a1, c2
Number of Weeks /and Units Per Semester		**14**	**28**	

C - Practical Aspect: Computer Laboratory				
Order	**Tasks/ Experiments**	**Number of Weeks**	**Contact hours**	**Learning Outcomes**
1.	Introduction to MATLAB	1	2	c2
2.	Write MATLAB codes: i) For verifying sampling theorem. ii) To represent basic signals like: Unit Impulse, Ramp, Unit Step, Exponential.	1	2	a1, c2
3.	Write MATLAB codes to: i) Generate discrete sine and cosine signals with given sampling frequency. ii) Represent complex exponential as a function of real and imaginary part.	1	2	a1, c2
4.	Write MATLAB codes to: i) Determine impulse and step response of two vectors using MATLAB. ii) Perform convolution between two vectors using MATLAB.	1	2	a1, b2, c2, d1

5.	Write a MATLAB code to perform cross correlation between two vectors using MATLAB	1	2	a1, b2, c2, d1
6.	Write a MATLAB code to compute DFT and IDFT of a given sequence using MATLAB.	1	2	a1, b1, b2, c2, d1
7.	Write a MATLAB code to perform linear convolution of two sequence using DFT using MATLAB.	1	2	a1, b1, c2, d1
8.	Write a MATLAB code to determine z-transform from the given transfer function and its ROC using MATLAB.	1	2	a1, b1, c2, d1
9.	Write a MATLAB code to design a Type 1 Chebyshev IIR highpass filter using MATLAB.	1	2	a1, c1, c2, d1
10.	Write a MATLAB code to design an IIR Elliptic low pass filter using MATLAB.	1	2	a1, b1, c2, d1
11.	Write a MATLAB code to design an IIR Butterworth bandpass filter using MATLAB.	1	2	a1, b1, c2, d1
12.	Write MATLAB codes to generate rectangular, Hamming, Hanning, Blackman, and Kaier windows using MATLAB.	1	2	a1, b1, b2, c1, c2, d1
13.	Write a MATLAB code to design low pass filter using the Kaiser window using MATLAB.	1	2	a1, b1, c2, d1
14.	Write a MATLAB code to study coefficient quantization effects on the frequency response of a cascade form IIR filter using MATLAB.	1	2	a1, a1, b2, c1, c2, d1
Number of Weeks /and Units Per Semester		**14**	**28**	

V. Teaching strategies of the course:

- Interactive Lectures
- Class discussions
- Problem Solving
- Computer-based Learning
- Independent readings
- Web based Investigations

Head of Department	Quality Assurance Unit	Dean of the Faculty	Academic Development Center & Quality Assurance	Rector of Sana'a University
Asst. Prof. Dr. Adel Ahmed Al-Shakiri	Assoc. Prof. Dr. Mohammad Algorafi	Prof. Dr. Mohammed AL-Bukhaiti	Assoc. Prof. Dr. Huda Al-Emad	Prof. Dr. Al-Qassim Mohammed Abbas

- Matlab Simulations

VI. Assignments:

No	Assignments	Aligned CILOs	Week Due	Mark
1.	Problems on Discrete-Time Signals and Systems, & Sampling and Reconstruction	a1, a2	3rd	2
2.	Problems on z-Transform and its Inverse	a1, b1	6th	2
3.	Problems on Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT	a1, b1, b2, c1,d1	10th	2
4.	Problems on Design of Finite Impulse Response (FIR) Filters	a1, c1, c2,d1	13th	2
5.	Problems on Design of Infinite Impulse Response (IIR) Filters	a1, c1, c2,d1	15th	2
	Total			**10**

VII. Schedule of Assessment Tasks for Students During the Semester:

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1.	Assignments	3rd, 6th, 10th, 13th, 15th	10	5%	a1, a2, b1, b2, c1, c2, d1
2.	Quizzes	4th, 13th	20	10%	b1, b2, c1, c2
3.	Attendance & Participation	Weekly	10	5%	a1
4.	Lab Reports	Weekly	20	10%	b1, b2, c1, c2
5.	Midterm Exam	7th	20	10%	a1, a2, b1

6.	Final Exam	16th	120	60%	a1, a2, b1, b2, c1, c2
Total			**200**	**100%**	

VIII. Learning Resources:

- *Written in the following order: (Author - Year of publication – Title – Edition – Place of publication – Publisher).*

1- Required Textbook(s) (maximum two).

1. Sanjit K. Mitra, 2011, "Digital Signal Processing: A computer-based approach", Fourth Edition, USA, McGraw Hill.

2- Essential References.

1. V. Oppenheim, R. W. Schafer, 1999, "Discrete-Time Signal Processing", Second Edition, USA, Prentice Hall.
2. J. G. Proakis and D.G. Manolakis, 2014, "Digital Signal Processing", Fourth Edition, UK, Pearson.
3. Richard G. Lyons, 2011, "Understanding digital signal processing", Prentice Hall PTR, Third Edition, USA, Pearson Education.

3- Electronic Materials and Web Sites *etc*.

1. Goggling the Internet

IX. Course Policies:

1.	**Class Attendance:** - The students should have more than 75% of attendance according to rules and regulations of the faculty.
2.	**Tardy:** - The students should respect the timing of attending the lectures. They should attend within 15 minutes from starting of the lecture.
3.	**Exam Attendance/Punctuality:** - The student should attend the exam on time. The punctuality should be implemented according to rules and regulations of the faculty for mid-term exam and final exam.

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4.	**Assignments & Projects:** - The assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time.
5.	**Cheating:** - If any cheating occurred during the examination, the student is not allowed to continue and he has to face the examination committee for enquires.
6.	**Plagiarism:** - If one student attends the exam on another behalf; he will be dismissed from the faculty according to the policy, rules and regulations of the university.
7.	**Other policies:** - All the teaching materials should be kept out the examination hall and mobile phones are not allowed. - Mutual respect should be maintained between the student and his teacher and also among students. Failing in keeping this respect is subject to the policy, rules and regulations of the university.

Reviewed By	**Vice Dean for Academic Affairs and Post Graduate Studies: Asst. Prof. Dr. Tarek A. Barakat** **President of Quality Assurance Unit: Assoc. Prof. Dr. Mohammed Algorafi** **Name of Reviewer from the Department: Asst. Prof. Dr. Mohammed Al-Suraby**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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