Sana'a University
Faculty of Engineering
Electrical Engineering Department
B.Sc. of Computer and Control Engineering

39. Course Specification of Analog Control Systems

I. Course Identification and General Information:

1.	Course Title:	Analog Control Systems				
2.	Course Code & Number:	CCE332				
3.	Credit hours:	C.H				Total
		Th.	Tu.	Pr.	Tr.	
		2	2	2	-	4
4.	Study level/ semester at which this course is offered:	Fourth Year/ First Semester				
5.	Pre –requisite (if any):	Signal and Systems (CNE216)				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Power Engineering and Electrical machines				
8.	Language of teaching the course:	English				
9.	Location of teaching the course:	Class				
10.	Prepared By:	Asst. Prof. Dr. Amin Abdelghani Mahyob				
11.	Date of Approval					

II. Course Description:

This introductory course, with lab, provides a theoretical and practical overview of classical analog control methods such as PID control and lag-lead control on automatic control. Students will learn how to apply the control theory to real engineering problems with Matlab and through laboratory experiments. Topics covered include characteristics, performance and design of feedback control systems in both time and frequency domains and examples of industrial

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	III. Course Intended learning outcomes (CILOs) of the course	Referenced PILOs
a1	Identify the components of the control system, the effects produced by the different controllers and the suitable controller for a specified task	A1,A2,A3
a2	Determine the effect of a control action and its parameters on the stability, sensitivity, steady states and transient responses	A1
b1	Analyze the characteristics of dynamics systems and their performances.	B2,B3
b2	Assess system stability accuracy and sensitivity.	B1,B2,B3
c1	Design the different types of compensators and controllers based on the transient and steady state response criteria	C1,C2
c2	Apply experimentally and computer Aided Tools, (MATLAB, Simulink) in analyzing dynamics control systems and different controllers.	C3,C4
d1	Interact effectively with peers in the group	D1,D4
d2	Present project results to a technical audience and subdivide a project into relevant sub problems and solve it in a given time frame as a team.	D1,D3,D5

(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. Identify the components of the control system, the effects produced by the different controllers and the suitable controller for a specified task	Lectures, Demonstrations, Software Simulation, Interactive class discussion.	Assignments, Oral Presentations, Quizzes, Tests, Written Exams.
a2. Determine the effect of a control action and its parameters on the stability,	Lectures, Demonstrations, Software Simulation, Interactive class discussion.	Assignments, Oral Presentations,

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sensitivity, steady states and transient responses		Quizzes, Tests, Written Exams.

(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 characteristics of dynamics systems and their performances.	Lectures, Demonstrations, Software Simulation, Interactive class discussion.	Assignments, Oral Presentations, Quizzes, Tests, Written Exams.
b2. Assess system stability accuracy and sensitivity.	Lectures, Demonstrations, Software Simulation, Interactive class discussion.	Assignments, Oral Presentations, Quizzes, Tests, Written Exams.

(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. Design the different types of compensators and controllers based on the transient and steady state response criteria	Lectures, Demonstrations, Software Simulation, Interactive class discussion.	Assignments, Oral Presentations, Quizzes, Tests, Written Exams.
c2. Apply experimentally and computer Aided Tools, (MATLAB, Simulink) in analyzing dynamics control systems and different controllers.	Lectures, Demonstrations, Software Simulation, Interactive class discussion.	Assignments, Oral Presentations, Quizzes, Tests, Written Exams.

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(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1. Interact effectively with peers in the group	Demonstrations, Software Simulation Interactive class discussion.	Assignments, Oral Presentations
d2. Present project results to a technical audience (Communication) and subdivide a project into relevant sub problems and solve it in a given time frame as a team. (Teamwork).	Software Simulation, Interactive class discussion.	Assignments, Oral Presentations.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact hours
1.	Introduction to Control Systems	a1, a2, b1, b2,	▪ Examples of Control Systems ▪ Regulator control system and position (servomechanism) control system ▪ SISO, MIMO systems ▪ Closed-Loop Control Versus Open-Loop Control ▪ Design of Control Systems	1	2

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2.	Performance (response) of Control Systems	a1, a2, b1, b2	▪ Test Input Signals ▪ Performance of First-Order Systems ▪ Performance of Second-Order Systems ▪ Effect of feedback on the performance of the system ▪ Control system specifications ▪ Effects of adding a new Pole or Zero on the System Response ▪ The s-Plane Root Location and the Transient Response ▪ The response of high order systems ▪ The Simplification of Linear Systems ▪ Performance Indices	2	4
3.	Characteristics of Feedback Control Systems	b1,b2,	▪ Configurations of feedback control systems ▪ Effects of controllers on the control system ▪ Stability analysis of control system: ▪ Relation between pole locations and stability ▪ Routh-Hurwitz criteria for stability ▪ Sensitivity of Control Systems to Parameter Variations	2	4

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			▪ Rejection of disturbance ▪ Control of the Transient Response ▪ Steady-State Error		
4.	The Root Locus Analysis	a1, a2, b1, b2, d2	▪ The Root Locus Concept (angle and magnitude criteria) and Procedure ▪ Stability and the root locus ▪ Transient response and root locus ▪ Negative Gain Root Locus ▪ Implementation of controllers using operational amplifier	1	2
5.	Frequency response analysis	a2, b1, b2, d1	▪ Frequency Response Plots:(Bod diagrams, Polar plot, Log Magnitude versus Phase plot) ▪ Frequency Response Measurements ▪ Stability in the Frequency Domain (absolute stability "Nyquist criterion", Relative stability) ▪ Performance Specifications in the Frequency Domain ▪ Closed loop frequency response ▪ Relations between performance Specifications	3	6

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			in the time and Frequency Domains		
6.	Feedback Control Design	b1,b2,c1,c2	▪ Approaches to System Design ▪ Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Root Locus ▪ Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Frequency Response ▪ System Design Using Integration Networks ▪ Systems with a Prefilter ▪ Design for Deadbeat Response	3	6
7.	Modern Control Design (State variables design)	All CILO's	▪ Pole placement design ▪ Ackermann's formula ▪ State Estimation (observer) ▪ Closed loop characteristic equation ▪ Reduced order estimator ▪ Controllability and Observability ▪ Systems with inputs	2	4
Number of Weeks /and Units Per Semester				**14**	**28**

B – Tutorial Aspect:

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Order	Tasks/ Experiments	Number of Weeks	Contact hours	Learning Outcomes
1.	• Linear and nonlinear systems • Introduction to Control Systems • SISO, MIMO systems • Open-Loop and Closed-Loop • Simple examples of Control Systems.	a1, a2, b1, b2,	1	2
2.	<u>Performance (response) of Control Systems:</u> • Test Input Signals • Performance of First-Order Systems • Performance of Second-Order Systems • Effect of feedback signal on the performance of the system response • Control system specifications and pole locations) • Effects of a Third Pole and a Zero on the Second-Order System Response • The response of high order systems • Reduced model of Linear Systems	a1, a2, b1, b2, d1, d2	2	4
3.	<u>Characteristics of Feedback Control Systems:</u> • Effects of controllers on transient and steady responses) • Stability analysis of control system:(, Routh-Hurwitz criterion for stability) • Sensitivity of Control Systems • Disturbance rejection • Steady-State Error	a1, a2, b1, b2, d1, d2	2	4

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4.	The Root Locus Method: • Root locus plot • Stability and the root locus • Transient response and root locus • Negative Gain Root Locus • Implementation of controllers using operational amplifier	a1, a2, b1, b2, d1, d2	1	2
5.	Frequency Response Methods: • Frequency Response Plots:(Bod diagrams, Polar plot, Log Magnitude versus Phase plot) • Minimum phase and non-minimum phase systems • Frequency Response Measurements • Stability in the Frequency Domain (Nyquist criterion, Relative stability margins)	a1, a2, b1, b2, d1, d2	2	4
6.	Feedback Control Design • Approaches to System Design • Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Root Locus • Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Frequency Response • System Design Using Integration Networks • Systems with a Prefilter • Design for Deadbeat Response	a1, a2, b1, b2, c1, c2, d1, d2	2.5	5
7.	Modern Control Design (State variables design) Modern) • Pole placement design • Ackermann's formula • State Estimation (observer) • Closed loop characteristic equation	a1, a2, b1, b2, c1, c2, d1, d2	1.5	3

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	• Reduced order estimator • Controllability and Observability • Systems with inputs			
8.	MatLab – Control Toolbox: • Computer Usage MATLAB software with Control Toolbox	a1, a2, b1, b2, c1, c2, d1, d2	2	4
Number of Weeks /and Units Per Semester			**14**	**28**

C - Practical Aspect:

Order	Tasks/ Experiments	Number of Weeks	Contact hours	Learning Outcomes
1.	• Introduction to Control System Lab • Lab safety rules and regulations **Controlled systems** • The controlled system, definition of items • Types of controlled systems, characteristics, examples	1	2	a1,b1
2.	**Controllers** • Definitions, characteristics **P Controller** • Characteristic of P controller • The proportional (P) controller response for various controlled system transfer coefficient • Relation between reference variable and proportionality coefficient Kp	1	2	b1,b2,c1,c2
3.	**Delayed closed loop control system of first order and second order** Definition of elements, Producing delay elements	1	2	b1,b2,c1,c2

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	Determination of controlled system TF coefficients Controllability of the system			
4.	**PI controller** • characteristic I element, Response of I controller to positive and negative signals • Characteristics of PI controller, Step response of PI controller, Parallel and Series configuration	1	2	b1,b2,c1,c2
5.	**PD controller** • Characteristics of PD controller, • Explanation of the derivative action, • Step response, of PI controller, Parallel and Series configuration	1	2	a1,b2,c1,c2,d1
6.	**PID controller** • Characteristics of PID controller • step response • **ramp response** • **parallel series configurations**	1	2	a2,b2,c1,c2,d2
7.	**P,PI,PD,PID controllers (stability, optimization)** • **Stability and stability margins** • **Maximum overshoot** • **Settling time** • **Optimization**		2	b1,b2,c1,c2
8.	**P,PI,PD,PID controllers (Ziegler- Nichols recommendations)** • **The critical proportionality coefficient Kpcri** • **The critical oscillation period Tcri** • **Setting recommendations according to Ziegler and Nichols**	1	2	b1,b2,c1,c2

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9.	**P,PI,PD,PID controllers (parallel and series configurations)** • **Advanced calculations for parallel configuration (mathematical controller)** • **Advanced calculations for series configuration (technical controller)**	1	2	b1,b2,c1,c2
10.	**P,PI,PD,PID controllers (closed loop control of fixed value, sequence and program)** • **Fixed value control, Sequence control, Time Program control** • **PID controller in a PT-4 controlled system** • **PI controller in a PT-4 controlled system** • **PD controller in a PT-4 controlled system** • **P controller in a PT-4 controlled system**	1	2	b1,b2,c1,c2
11.	**Frequency response measurements:** • **Measure and plot the frequency response of a RLC circuit,** • **determine the transfer function of the system** • **determine the parameters of the circuits**	1	2	a2,b2,c1,c2
12.	**Using MATLAB, Control Toolbox, and Simulink:** • Study the time and frequency response of dynamic system • Determine the speed of response and accuracy Root locus and Bode Plots	1	2	b1,b2,c1,c2,d2

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	• Parameter Identification, P, PI, PD/PID Control, Position Control, regulator control • Steady State Error and Stability Analysis			
13.	**Projects:** Student make groups of 3-4 students each group is required to choose a lab project (build, simulate, make a proto type) of a control system. The flowing are some examples of industrial control systems - Temperature Control with a two-Position Controller - Temperature Control with a PID Controller - Liquid Level Control with a two-Position Controller - Liquid Level Control with a PID Controller - DC. Motor Speed Control - Voltage Regulation of a dc generator - Position Control System - Speed Control System	2	4	b1,b2,c1,c2,d1
Number of Weeks /and Units Per Semester		**14**	**28**	

V. Teaching strategies of the course:

- Lectures
- Interactive class discussion
- Demonstration
- Software Simulation

VI. Assignments:

Order	Assignments	Aligned CILOs (symbols)	Week Due	Mark

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1.	Open-Loop and closed-Loop	a1, c1,d2	2	2.5
2.	Effects of controllers on transient and steady responses)	a2, c2,d2	4	2.5
3.	Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Frequency Response	c1, d1, d2	8	2.5
4.	Pole placement design and Ackermann's formula	b1, c2, d2	12	2.5
5.	MATLAB Applications	b2, c2, d1, d2	14	10
Total				**20**

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	Quizzes	4^{th}, 7^{th},10^{th}, and 13^{th}	20	10%	a1,a2,b1,b2
2	Assignments	Weekly	20	10%	a1,a2,b1,b2,d2
3	Mid-Term exam	7^{th}	30	15%	a1,a2,b1,b2
4	Practical exam	15^{th}	30	15%	b1,b2,c1,c2
5	Final Exam theory	16^{th}	100	50%	a1,a2,b1,b2
	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. Charles L. Philips and Royce Harbor " Feedback control systems", fourth edition, Prentice Hall.
2. Richard C. Dorf and Robert H. Bishop, Modern Control Systems (12th Edition), Prentice Hall.

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2- Essential References.
1. K. Ogata, 1997, Modern Control Engineering, 3rd Edition, Prentice Hall.- **2.** Norman S. Nise, 2011, Control Systems Engineering (Sixth edition). **3.** Supplemental materials - Schaum's outline of theory and problems of feedback and control systems, by McGraw Hill Publisher.
3- Electronic Materials and Web Sites etc.
1. Modelica Association (2000). ModelicaTM - A Unified Object-Oriented Language for Physical Systems Modeling. Tutorial Version 1.4 (ModelicaTutorial14.pdf). Available from: https://modelica.org/documents/ **2.** MapleSim Video Tutorial: Modelica Video lectures available form: http://www.youtube.com/watch?v=reehU1dzeDc. **3.** Simulink-Matlab tutorial for beginners Video lectures available form: **4.** http://www.youtube.com/results?search_query=simulink+tutorial+for+beginners&oq=simulink&gs_l=youtube.1.9.0l10.337429.342148.0.351270.8.8.0.0.0.0.738.2481.3j3-2j2j0j1.8.0...0.0...1ac.1.11.youtube.iIK7kMX6hfo-

IX. Course Policies:

1.	**Class Attendance:** -A student should attend not less than 75 % of total hours of the subject; otherwise he will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic
2.	**Tardy:** - For late in attending the class, the student will be initially notified. If he repeated lateness in attending class he will be considered as absent.
3.	**Exam Attendance/Punctuality:** - A student should attend the exam on time. He is Permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam.
4.	**Assignments & Projects:**

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	- The assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time.
5.	**Cheating**: - For cheating in exam, a student will be considered as failure. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6.	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university.
7.	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room - Mobile phones are not allowed in class during the examination. Lecture notes and assignments my given directly to students using soft or hard copy

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: Assoc. Prof. Dr. Radwan Al bouthigy**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

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39. Template for Course Plan of Analog Control Systems

Information about Faculty Member Responsible for the Course:							
Name of Faculty Member	Dr. Amin Abdelghani H. Mahyob	**Office Hours**					
Location& Telephone No.	770249615	**SAT**	**SUN**	**MON**	**TUE**	**WED**	**THU**
E-mail	amin.mahyob@gmail.com						

II. Course Identification and General Information:						
1.	Course Title:	Analog Control Systems				
2.	Course Code & Number:	CCE332				
3.	Credit hours:	C.H				Total
		Th.	Tu.	Pr	Tr.	
		2	2	2	-	4
4.	Study level/ semester at which this course is offered:	Fourth year/First Semester				
5.	Pre –requisite (if any):	Signal and systems (CNE216)				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	Electrical power and machines				
8.	Language of teaching the course:	English				
9.	System of Study:	Regular				
10.	Mode of delivery:	Semesters.				
11.	Location of teaching the course:	Class				

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III. Course Description:

This introductory course, with lab, provides a theoretical and practical overview of classical analog control methods such as PID control and lag-lead control on automatic control. Students will learn how to apply the control theory to real engineering problems with Matlab and through laboratory experiments. Topics covered include characteristics, performance and design of feedback control systems in both time and frequency domains and examples of industrial.

IV. Intended learning outcomes (ILOs) of the course:

- Brief summary of the knowledge or skill the course is intended to develop**:**

1. Identify the components of the control system, the effects produced by the different controllers and the suitable controller for a specified task
2. Determine the effect of a control action and its parameters on the stability, sensitivity, steady states and transient responses
3. Analyze the characteristics of dynamics systems and their performances.
4. Assess system stability accuracy and sensitivity.
5. Design the different types of compensators and controllers based on the transient and steady state response criteria
6. Apply experimentally and computer Aided Tools, (MATLAB, Simulink) in analyzing dynamics control systems and different controllers.
7. Interact effectively with peers in the group
8. Present project results to a technical audience and subdivide a project into relevant sub problems and solve it in a given time frame as a team.

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V. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Number of Weeks	Contact hours
1.	Introduction to Control Systems	▪ Examples of Control Systems ▪ Regulator control system and position (servomechanism) control system ▪ SISO, MIMO systems ▪ Closed-Loop Control Versus Open-Loop Control ▪ Design of Control Systems	1st	2
2.	Performance (response) of Control Systems	▪ Test Input Signals ▪ Performance of First-Order Systems ▪ Performance of Second-Order Systems ▪ Effect of feedback on the performance of the system ▪ Control system specifications ▪ Effects of adding a new Pole or Zero on the System Response ▪ The s-Plane Root Location and the Transient Response ▪ The response of high order systems ▪ The Simplification of Linear Systems ▪ Performance Indices	2nd ,3rd	4
3.	Characteristics of Feedback Control Systems	▪ Configurations of feedback control systems ▪ Effects of controllers on the control system ▪ Stability analysis of control system:	4th , 5th	4

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		▪ Relation between pole locations and stability ▪ Routh-Hurwitz criteria for stability ▪ Sensitivity of Control Systems to Parameter Variations ▪ Rejection of disturbance ▪ Control of the Transient Response ▪ Steady-State Error		
4.	The Root Locus Analysis	▪ The Root Locus Concept (angle and magnitude criteria) and Procedure ▪ Stability and the root locus ▪ Transient response and root locus ▪ Negative Gain Root Locus ▪ Implementation of controllers using operational amplifier	6^{th}	2
5.	Midterm exam	▪	7^{th}	2
6.	Frequency response analysis	▪ Frequency Response Plots:(Bod diagrams, Polar plot, Log Magnitude versus Phase plot) ▪ Frequency Response Measurements ▪ Stability in the Frequency Domain (absolute stability "Nyquist criterion", Relative stability) ▪ Performance Specifications in the Frequency Domain ▪ Closed loop frequency response ▪ Relations between performance Specifications in the time and Frequency Domains	8^{th} ,9^{th} ,10^{th}	6
7.	Feedback Control Design	▪ Approaches to System Design	11^{th} ,12^{th} ,13^{th}	6

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		▪ Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Root Locus ▪ Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Frequency Response ▪ System Design Using Integration Networks ▪ Systems with a Prefilter ▪ Design for Deadbeat Response		
8.	Modern Control Design (State variables design)	▪ Pole placement design ▪ Ackermann's formula ▪ State Estimation (observer) ▪ Closed loop characteristic equation ▪ Reduced order estimator ▪ Controllability and Observability ▪ Systems with inputs	14^{th} ,15^{th}	4
9.	Final exam.		16^{th}	2
Number of Weeks /and Units Per Semester			**16**	**32**

B – Tutorial Aspect:

Order	Tasks/ Experiments	Contact hours	Learning Outcomes
1.	• Linear and nonlinear systems • Introduction to Control Systems • SISO, MIMO systems • Open-Loop and Closed-Loop • Simple examples of Control Systems.	1^{st}	2
2.	Performance (response) of Control Systems: • Test Input Signals	2^{nd} ,3^{rd}	4

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	• Performance of First-Order Systems • Performance of Second-Order Systems • Effect of feedback signal on the performance of the system response • Control system specifications and pole locations) • Effects of a Third Pole and a Zero on the Second-Order System Response • The response of high order systems • Reduced model of Linear Systems		
3.	<u>Characteristics of Feedback Control Systems:</u> • Effects of controllers on transient and steady responses) • Stability analysis of control system:(, Routh-Hurwitz criterion for stability) • Sensitivity of Control Systems • Disturbance rejection • Steady-State Error	4^{th} ,5^{th}	4
4.	<u>The Root Locus Method:</u> • Root locus plot • Stability and the root locus • Transient response and root locus • Negative Gain Root Locus • Implementation of controllers using operational amplifier	6^{th}	2
5.	<u>Frequency Response Methods:</u> • Frequency Response Plots:(Bod diagrams, Polar plot, Log Magnitude versus Phase plot) • Minimum phase and non-minimum phase systems • Frequency Response Measurements • Stability in the Frequency Domain (Nyquist criterion, Relative stability margins)	7^{th} ,8^{th}	4

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6.	Feedback Control Design • Approaches to System Design • Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Root Locus • Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Frequency Response • System Design Using Integration Networks • Systems with a Prefilter • Design for Deadbeat Response	9^{th} ,10^{th} 11^{th}	5
7.	Modern Control Design (State variables design) Modern) • Pole placement design • Ackermann's formula • State Estimation (observer) • Closed loop characteristic equation • Reduced order estimator • Controllability and Observability • Systems with inputs	11^{th} ,12^{th}	3
8.	MatLab – Control Toolbox: • Computer Usage MATLAB software with Control Toolbox	13^{th} ,14^{th}	4
Number of Weeks /and Units Per Semester		**14**	**28**

C - Practical Aspect: (if any)

Order	Tasks/ Experiments	Number of Weeks	Contact hours	Learning Outcomes
1.	• Introduction to Control System Lab • Lab safety rules and regulations **Controlled systems** • The controlled system, definition of items	1^{st}	2	a1,b1

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	• Types of controlled systems, characteristics, examples			
2.	**Controllers** • Definitions, characteristics **P Controller** • Characteristic of P controller • The proportional (P) controller response for various controlled system transfer coefficient • Relation between reference variable and proportionality coefficient Kp	2nd	2	b1,b2,c1,c2
3.	**Delayed closed loop control system of first order and second order** Definition of elements, Producing delay elements Determination of controlled system TF coefficients Controllability of the system	3rd	2	b1,b2,c1,c2
4.	**PI controller** • characteristic I element, Response of I controller to positive and negative signals • Characteristics of PI controller, Step response of PI controller, Parallel and Series configuration	4th	2	b1,b2,c1,c2
5.	**PD controller** • Characteristics of PD controller, • Explanation of the derivative action, • Step response, of PI controller, Parallel and Series configuration	5th	2	a1,b2,c1,c2,d1
6.	**PID controller** • Characteristics of PID controller • step response • **ramp response**	6th	2	a2,b2,c1,c2,d2

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	• **parallel series configurations**			
7.	**P,PI,PD,PID controllers (stability, optimization)** • **Stability and stability margins** • **Maximum overshoot** • **Settling time** • **Optimization**	7th	2	b1,b2,c1,c2
8.	**P,PI,PD,PID controllers (Ziegler- Nichols recommendations)** • **The critical proportionality coefficient Kpcri** • **The critical oscillation period Tcri** • **Setting recommendations according to Ziegler and Nichols**	8th	2	b1,b2,c1,c2
9.	**P,PI,PD,PID controllers (parallel and series configurations)** • **Advanced calculations for parallel configuration (mathematical controller)** • **Advanced calculations for series configuration (technical controller)**	9th	2	b1,b2,c1,c2
10.	**P,PI,PD,PID controllers (closed loop control of fixed value, sequence and program)** • **Fixed value control, Sequence control, Time Program control** • **PID controller in a PT-4 controlled system** • **PI controller in a PT-4 controlled system** • **PD controller in a PT-4 controlled system** • **P controller in a PT-4 controlled system**	10th	2	b1,b2,c1,c2

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11.	**<u>Frequency response measurements</u>:** • **Measure and plot the frequency response of a RLC circuit,** • **determine the transfer function of the system** • **determine the parameters of the circuits**	11th	2	a2,b2,c1,c2
12.	**<u>Using MATLAB, Control Toolbox, and Simulink</u>**: • Study the time and frequency response of dynamic system • Determine the speed of response and accuracy Root locus and Bode Plots • Parameter Identification, P, PI, PD/PID Control, Position Control, regulator control • Steady State Error and Stability Analysis	12th	2	b1,b2,c1,c2,d2
13.	**<u>Projects:</u>** Student make groups of 3-4 students each group is required to choose a lab project (build, simulate, make a proto type) of a control system. The flowing are some examples of industrial control systems - Temperature Control with a two-Position Controller - Temperature Control with a PID Controller - Liquid Level Control with a two-Position Controller - Liquid Level Control with a PID Controller - DC. Motor Speed Control - Voltage Regulation of a dc generator - Position Control System - Speed Control System	13th ,14th	4	b1,b2,c1,c2,d1

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Number of Weeks /and Units Per Semester	14	28	

VI. Teaching strategies of the course:

- Lectures
- Interactive class discussion
- Demonstration
- Software Simulation

VII. Assignments:

Order	Assignments	Aligned CILOs (symbols)	Week Due	Mark
1.	Open-Loop and closed-Loop	a1, c1,d2	2	2.5
2.	Effects of controllers on transient and steady responses)	a2, c2,d2	4	2.5
3.	Design of: Phase lead, phase lag, lag-lead and PID Controllers using the Frequency Response	c1, d1, d2	8	2.5
4.	Pole placement design and Ackermann's formula	b1, c2, d2	12	2.5
5.	MATLAB Applications	b2, c2, d1, d2	14	10
Total				**20**

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

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1.	Quizzes	4th,7th,10th, and 13th	20	10%
2.	Assignments	Weekly	20	10%
3.	Mid-Term exam	7th	30	15%

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4.	Practical exam	15th	30	15%
5.	Final Exam theory	16th	100	50%
	Total		**200**	**100%**

IX. Learning Resources:

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

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

1. Charles L. Philips and Royce Harbor " Feedback control systems", fourth edition, Prentice Hall.
2. Richard C. Dorf and Robert H. Bishop, Modern Control Systems (12th Edition), Prentice Hall.-

2- Essential References.

1. K. Ogata, 1997, Modern Control Engineering, 3rd Edition, Prentice Hall.-
2. Norman S. Nise, 2011, Control Systems Engineering (Sixth edition).
3. Supplemental materials - Schaum's outline of theory and problems of feedback and control systems, by McGraw Hill Publisher.

3- Electronic Materials and Web Sites etc.

1. Modelica Association (2000). ModelicaTM - A Unified Object-Oriented Language for Physical Systems Modeling. Tutorial Version 1.4 (ModelicaTutorial14.pdf). Available from: https://modelica.org/documents/
2. MapleSim Video Tutorial: Modelica Video lectures available form: http://www.youtube.com/watch?v=reehU1dzeDc.
3. Simulink-Matlab tutorial for beginners Video lectures available form:
4. http://www.youtube.com/results?search_query=simulink+tutorial+for+beginners&oq=simulink&gs_l=youtube.1.9.0l10.337429.342148.0.351270.8.8.0.0.0.0.738.2481.3j3-2j2j0j1.8.0...0.0...1ac.1.11.youtube.iIK7kMX6hfo-

X. Course Policies:

1. Class Attendance:

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	-A student should attend not less than 75 % of total hours of the subject; otherwise he will not be able to take the exam and will be considered as exam failure. If the student is absent due to illness, he/she should bring an approved statement from university Clinic
2.	**Tardy:** - For late in attending the class, the student will be initially notified. If he repeated lateness in attending class he will be considered as absent.
3.	**Exam Attendance/Punctuality:** - A student should attend the exam on time. He is Permitted to attend an exam half one hour from exam beginning, after that he/she will not be permitted to take the exam and he/she will be considered as absent in exam.
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**: - For cheating in exam, a student will be considered as fail. In case the cheating is repeated three times during his/her study the student will be disengaged from the Faculty.
6.	**Plagiarism**: Plagiarism is the attending of a student the exam of a course instead of another student. If the examination committee proved a plagiarism of a student, he will be disengaged from the Faculty. The final disengagement of the student from the Faculty should be confirmed from the Student Council Affair of the university.
7.	**Other policies:** - Mobile phones are not allowed to use during a class lecture. It must be closed, otherwise the student will be asked to leave the lecture room - Mobile phones are not allowed in class during the examination. Lecture notes and assignments my given directly to students using soft or hard copy

40. Course Specification of Computer Architecture and Organization

Prepared by	Head of Department	Quality Assurance Unit	Dean of the Faculty	Academic Development Center & Quality Assurance
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I. Course Identification and General Information

1.	Course Title:	Computer Architecture and Organization				
2.	Course Code &Number:	CCE315				
3.	Credit hours:	C.H				TOTAL
		Th.	Tu.	Pr.	Tr.	
		2	2	-	-	3
4.	Study level/ semester at which this course is offered:	Fourth Year/ First Semester				
5.	Pre –requisite (if any):	Microprocessors & Assembly Language (CCE214)				
6.	Co –requisite (if any):	None.				
7.	Program (s) in which the course is offered:	B.Sc. of Computer and Control Engineering				
8.	Language of teaching the course:	Arabic & English				
9.	Location of teaching the course:	Class Room (Faculty of Engineering)				
10.	Prepared By:	Prof. Abdul Raqib Abdo Asaad				
11.	Date of Approval					

II. Course Description

This course covers computer architecture, organization, performance, computer components, computer memory system, I/O modules, instruction sets, processor structure and function, control unit operation, and parallel organization.
This course depends on lectures and tutorials parts. In addition, it depends on Microprocessor and Assembly Language, and Programming Language (II) as prerequisites.

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III. Course Aims

This course aims to:

1. Understand the difference between computer organization and computer architecture.
2. Understand the concepts of computer performance and how to evaluate the performance of a digital computer.
3. Gain knowledge about computer memory system and I/O subsystems.
4. Understand the structure and function of computer processor.
5. Have knowledge of parallel organization and parallel processing.

IV. Course Intended learning outcomes (CILOs) of the course		Referenced PILOs
a1	Classify and list the different types of computer organizations and architectures.	A1 (E)
a2	Recognize the efficiency design of a digital computer and its units.	A2 (E)
b1	Compose the main units of a digital computer.	B1 (E)
b2	Evaluate the different solutions to enhance computer performance.	B2, B4 (E)
c1	Design the main units of a digital computer according to the selected instruction set, and to meet desired performance.	C2 (E)
c2	Use simulation programs to design digital computer units.	C4 (E)
d1	Perform specific tasks individually and make a discussion group.	D1, D2, D4, D5 (E)
d2	Follow the standards to achieve his reports and presentations.	

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

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a1 Classify and list the different types of computer organizations and architectures.	▪ Lectures ▪ Dialogue and discussion ▪ Self-learning	▪ Written Test and Quizzes ▪ Reports evaluation ▪ Presentations evaluation
a2 Recognize the efficiency design of a digital computer and its units.	▪ Lectures ▪ Tutorials	▪ Written Test and Quizzes ▪ Reports evaluation

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
b1 Compose the main units of a digital computer.	▪ Lectures ▪ Dialogue and discussion ▪ Tutorials	▪ Written Test and Quizzes ▪ Reports evaluation
b2 Evaluate the different solutions to enhance computer performance.	▪ Lectures ▪ Problems solving	▪ Written Test and Quizzes ▪ Reports evaluation

(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 Design the main units of a digital computer according to the selected instruction set, and to meet desired performance.	▪ Lectures ▪ Dialogue and discussion. ▪ Design exercises	▪ Written Test and Quizzes ▪ Coursework assignments

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c2	Use simulation programs to design digital computer units.	▪ Lectures ▪ Dialogue and discussion. ▪ Design exercises	▪ Written Test and Quizzes ▪ Coursework assignments

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(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies		
Course Intended Learning Outcomes	**Teaching strategies**	**Assessment Strategies**
d1 Perform specific tasks individually and make a discussion group.	▪ Tutorials ▪ Self-learning ▪ Dialogue and discussion	▪ Observation and interviews ▪ Presentations evaluation ▪ Reports evaluation
d2 Follow the standards to achieve his reports and presentations.	▪ Presentation Self-learning	▪ Report, Presentations evaluation ▪ Reports evaluation

V. Course Content

A – Theoretical Aspect

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	Contact hours
1.	Introduction to Computer Architecture and Design	a1, a2, b1, b2, c1	▪ Computer organization ▪ Architecture ▪ Function ▪ Designing for performance ▪ Computer component ▪ Interconnection structure	2	4
2.	Computer Memory System	a1, a2, b1, b2, c1, d1, d2	▪ Memory system (Internal Memory, External Memory) ▪ Cache memory principle ▪ Elements of cache design	3	6

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3.	I/O subsystems	a1, a2, b1, b2, c1, d1, d2	▪ Input subsystem ▪ Output subsystem	2	4
4.	Instruction Sets	a1, a2, b1, b2, c1	▪ Characteristics ▪ Function ▪ Addressing modes ▪ Format	2	4
5.	Processor Structure and Functions	a1, a2, b1, b2, c1	▪ Processor organization ▪ Register organization	2	4
6.	Control Unit Operations	a2, b1, b2, c1	▪ Fetch cycle ▪ Indirect cycle ▪ Execute cycle ▪ Interrupt cycle ▪ Instruction cycle	2	4
7.	Introduction to Parallel Organization and Processing	a1, a2, b1, b2	▪ Parallel organization ▪ Parallel processing	1	2
Number of Weeks /and Units Per Semester				**14**	**28**

B - Tutorial Aspect

Order	Topics List	Number of Weeks	Contact hours	Learning Outcomes
1.	Introduction to Computer Architecture and Design (Computer organization, Architecture, Function, Designing for performance, Computer component, Interconnection structure)	2	4	a1, a2, b1, b2, c1
2.	Computer Memory System (Memory system (Internal Memory, External Memory), Cache memory principle, Elements of cache design)	3	6	a1, a2, b1, b2, c1, d1, d2

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3.	Input / Output subsystems	2	4	a1, a2, b1, b2, c1, d1, d2
4.	Instruction Sets (Characteristics, Function, Addressing modes, Format)	2	4	a1, a2, b1, b2, c1, c2
5.	Processor Structure and Functions (Processor organization, Register organization)	2	4	a1, a2, b1, b2, c1
6.	Control Unit Operations (Fetch cycle, Indirect cycle, Execute cycle, Interrupt cycle, Instruction cycle)	2	4	a2, b1, b2, c1, c2
7.	Introduction to Parallel Organization and Processing	1	2	a1, a2, b1, b2
Number of Weeks /and Units Per Semester		**14**	**28**	

VI. Teaching strategies of the course

- Lectures
- Dialogue and discussion
- Lectures
- Tutorials
- Problems solving
- Design exercises
- Self-learning

VII. Assignments

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Project Researches	a1, d1, d2	3rd	5
2	Problems and Exercises Reports	a2, b1, b2, c1, c2, d1, d2	Weekly	5
	Total			**10**

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VIII. Schedule of Assessment Tasks for Students during the Semester

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1.	Researches	3rd	7.5	5%	a1, d1, d2
2.	Problems and Exercises Reports	Weekly	7.5	5%	a2, b1, b2, c1, c2, d1, d2
3.	Quizzes	4th, 6th, and 14th	15	10%	a1, a2, b1, b2, c1
4.	Midterm Exam	8th	30	20%	a1, a2, b1, b2, c1
5.	Final Exam	16th	90	60%	a1, a2, b1, b2, c1
Total			**150**	**100%**	

IX. Learning Resources

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

1- Required Textbook(s) (maximum two)

1) W. Stalling, (2003), "Computer Organization & Architecture: Designing for Performance", Prentice Hall.
2) M. Morris R. Mano (1992), "Computer System Architecture", Third Edition, Pearson.

2- Essential References

1) John P. Hayes (1997), "Computer Architecture and Organization", Third Edition. McGraw-Hill.

3- Electronic Materials and Web Sites etc.

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X. Course Policies	
1.	**Class Attendance:** The regulations are applied, which state that a student who desires more than 25% of attending lectures is deprived of the final examination.
2.	**Tardy:** If the student is late for attending the lecture time, his degree will be deducted for each delay in the attendance grades.
3.	**Exam Attendance/Punctuality:** The student must rely on himself for exam.
4.	**Assignments & Projects:** None.
5.	**Cheating:** If the student is caught cheating, he will be deprived of the exam in the subject.
6.	**Plagiarism**: In the case of student impersonation, the Vice Dean foe Student Affairs will be referred to the College's Student Affairs Committee the necessary action.
7.	**Other Policies**: If the student dose not attend more than 75% in the process, he will be deprived of the practical exam.

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. Adel Ahmed Al-Shakiri**
	Deputy Rector for Academic Affairs Asst. Prof. Dr. Ibrahim AlMutaa **Assoc. Prof. Dr. Ahmed Mujahed** **Asst. Prof. Dr. Munasar Alsubri**

Prepared by	Head of Department Asst. Prof. Dr. Adel Ahmed Al-Shakiri	Quality Assurance Unit Assoc. Prof. Dr. Mohammad Algorafi	Dean of the Faculty Prof. Dr. Mohammed AL-Bukhaiti	Academic Development Center & Quality Assurance Assoc. Prof. Dr. Huda Al-Emad

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