University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Course Specification of Digital Control Systems

Course Code (BE352)

I. Course Identification and General Information:						
1	**Course Title:**	Digital Control Systems				
2	**Course Code & Number:**	BE352				
3	**Credit hours:**	C.H				TOTAL
		Th.	Seminar	Pr	Tr.	
		2	--	2	2	4
4	**Study level/ semester at which this course is offered:**	4^{th} Level / 1^{st} Semester				
5	**Pre –requisite (if any):**	Analog Control Systems (BE251)				
6	**Co –requisite (if any):**	Microprocessor and Microcontrollers (BE353).				
7	**Program (s) in which the course is offered:**	Biomedical Engineering Program				
8	**Language of teaching the course:**	English				
9	**Location of Teaching the Course:**	Faculty of Engineering				
10	**Prepared by:**	Dr. Mohammed Al-Olofi				
11	**Reviewed by:**	Dr. Waleed Al-talabi				
12	**Date of Approval:**					

I. Course Description:

The Digital Control Systems course aims to give the student knowledge of the basic concepts and Theories of modeling, development, analysis, design and implement of modern and digital control

systems. This course includes the basic principles of digital control systems, quantization and quantization errors, data acquisitions, Z-transform and its applications to solve difference equations, Z plane analysis for discrete time control systems, impulse sampling, pulse transfer function, PID digital controllers realization and implementation, mapping between continuous –time control systems and discrete-time control systems, stability analysis, transient and steady state response, conventional and modern design methods of digital control systems, root-locus and bode plot design methods, analytical design methods, state space representation, controllability, observability, and servo-controllers. The practical part allows students to practice different digital control approaches studied in theoretical classes.

III. Course Intended learning outcomes (CILOs) of the course (maximum 8CILOs)		**Referenced PILOs** (Only write code number of referenced Program Intended learning outcomes)
Knowledge and Understanding: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
a1	Understand the concepts, theories, and mathematical modeling of Digital systems in pulse transfer function model and state variable model.	A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context.
a2	Explain how different analysis techniques are used to determine the specifications of digital control systems, and common design methods for design a digital controllers.	A4 Understand and give examples of design methods, knowledge tools, analytical skills, measurement techniques and methodologies for innovative and creative engineering solutions applied to healthcare problems and quality of life issues.
B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
b1	Apply common conventional and	B1 Apply engineering principles; basic of life-

تعليق عليه [l1]: Show understanding

تعليق عليه [l2]: هذا الفعل يستدم للتعبير عن المهارات العملية لذلك استخدم فعل أخر يتناسب مع المهارات الذهنية

	modern engineering methods to model, analyze, and organize the digital biomedical systems.	science; mathematical theories; and modern tools professionally in modelling, analyzing, designing, and constructing physical digital systems; devices and/or processes relevant to Biomedical Engineering fields.
b2	Analysis, and evaluate the biomedical engineering systems using the modern control engineering tools, then select a suitable digital controller for biomedical systems.	B2 Identify, formulate and solve the complex problems related to the Biomedical Engineering fields in a creative and innovative manner by using a systematic and analytical thinking methods.
b3	Design the digital controllers, and others components of the medical devices by using the control system design methods.	B3 Design the biomedical systems or processes within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
c1	Use the modern engineering tools, and analytical techniques to evaluate performance characteristics of different types of plant and process, and applying the knowledge to design, and implement a digital control systems.	C2 Use a wide range of analytical tools, techniques, IT, modern engineering tools, software packages and develop required computer programs to solve, modeling and analyzing Biomedical Engineering problems.
c2	Conduct appropriate experimentation related to a digital	C3 Use computational facilities and techniques, measuring instruments, workshops and laboratory equipment to design and conduct

تعليق عليه [l3]: استخدم فعل واحد فقط للتعبير عن مخرج المقرر

تعليق عليه [l4]: هذا الفعل يستدم للتعبير عن المهارات العملية لذلك استخدم فعل أخر يتناسب مع المهارات الذهنية

	control systems, and Locate different type of digital controllers used in real medical equipment.	experiments, collect, analyse and interpret data and present results in the biomedical systems practice.
D. Transferable Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
d1	Lead, and work productively as an individual and as a member of a team / multi-disciplinary team.	D1 Lead and motivate individuals, show capability to work in stressful environments and within constraints, collaborate effectively within multidisciplinary team.

تعليق عليه [I5]: استخدم فعل واحد فقط للتعبير عن مخرج المقرر

(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 Understand the concepts, theories, and mathematical modeling of Digital systems in pulse transfer function model and state variable model.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Computer laboratory-based sessions, • Directed self- study, • Problem based learning,	• Written tests (mid and final terms and quizzes), • Short reports, • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.
a2 Explain how different	• Interactive lectures &	• Written tests (mid and

تعليق عليه [I6]: صحح الفعل

analysis techniques are used to determine the specifications of digital control systems, and common design methods for design a digital controllers.	examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Mini/major project.	final terms and quizzes), • Oral exams, • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

(B) Alignment Course Intended Learning Outcomes of Intellectual Skills to Teaching Strategies and Assessment Strategies:

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
b1 Apply common conventional and modern engineering methods to model, analyze, and organize the digital biomedical systems.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies,	• Written tests (mid and final terms and quizzes), • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities

غير الفعل **تعليق عليه [7]:**

	• Exercises and home works, • Laboratory/Practical experiments based session, • Workshops practices, • Directed self- study, • Problem based learning, • Mini/major project.	assessment, • Home works and assignments, • Presentations.
b2 Analysis, and evaluate the biomedical engineering systems using the modern control engineering tools, then select a suitable digital controller for biomedical systems.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Mini/major project.	• Written tests (mid and final terms and quizzes), • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.
b3 Design the digital controllers, and others	• Interactive lectures & examples, • Tutorials,	• Written tests (mid and final terms and quizzes),

احذف أحد الفعلين **تعليق عليه [I8]:**

غير الفعل **تعليق عليه [I9]:**

components of the medical devices by using the control system design methods.	• Interactive class discussions, • Case studies, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	• Oral exams, • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

(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 Use the modern engineering tools, and analytical techniques to evaluate performance characteristics of different types of plant and process, and applying the knowledge to design, and implement a digital control systems.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Laboratory/Practical experiments based	• Written tests (mid and final terms and quizzes), • Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and

	session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	assignments, • Presentations.
c2 Conduct appropriate experimentation related to a digital control systems, and Locate different type of digital controllers used in real medical equipment.	• Interactive lectures & examples, • Tutorials, • Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Directed self- study, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	• Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1 Lead, and work productively as an individual and as a member of a team / multi-disciplinary team.	• Videos demonstrations, • Presentation/seminar, • Interactive class discussions, • Case studies, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Workshops practices, • Problem based learning, • Team work (cooperative learning), • Field visits/training, • Mini/major project.	• Short reports, • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Presentations.

تعليق عليه [l10]: احذف أحد الفعلين

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Learning Outcomes	Sub Topics List	Number of Weeks	contact hours
1	**Introduction to discrete- time control systems**	**a1, a2**	– Introduction of digital control systems, – types of digital control systems, quantization	**1**	**2**

تعليق عليه [l11]: يتم حذف الاختبارين النصفي والنهائي من المحتوي ويضافان فقط لخطة المقرر بحيث يصبح هنا عدد الأسابيع 14 وعدد الساعات 28

			methods, – data acquisition.		
2	**The Z-Transform**	**a1, a2**	– Introduction, – Z-transform, Z-transform of elementary function, – properties and theorems of z-transform, – Inverse Z-transform, – solve the difference equations of digital control systems, – example problems and solutions.	**1**	**2**
3	**The Z-plane analysis of discrete-time control systems**	**a1, a2, b1, b2, b3**	– Impulse sampling and data holding, – components of digital control systems, – pulse transfer function, – reduction block diagram in digital control systems, – example problems and solutions.	**1**	**2**
4	**The Z-plane analysis of discrete-time control systems**	**a1, a2, b1, b2, b3**	– PID digital controllers, – realization and implementation of digital controllers, – microcontroller implementation to digital controllers, – select the sampling interval, – example problems and	**1**	**2**

			solutions.		
5	**Design of discrete-time control systems by the conventional methods**	**a2, b1, b2, b3, c1, c2**	– Introduction to design methods, – mapping between s-plane and z-plane, – example problems and solutions.	**1**	**2**
6	**Design of discrete-time control systems by the conventional methods**	**a2, b1, b2, b3, c1, c2**	– Transient and steady state response analysis of feedback digital control systems, – example problems and solutions..	**1**	**2**
7	**Design of discrete-time control systems by the conventional methods**	**a2, b1, b2, b3, c1, c2**	– Introduction to conventional design methods, – the root locus method, – design based the root locus method, – example problems and solutions	**1**	**2**
8	**Mid-Term Theoretical Exam**	**a1, a2, b1, b2, b3, c1, c2**	– Previous Topics	**1**	**2**
9	**Design of discrete-time control systems by the conventional methods**	**a2, b1, b2, b3, c1, c2**	– Frequency response methods, – bode plot, – design based on the Frequency response methods, – example problems and	**1**	**2**

			solutions.		
10	**Design of discrete-time control systems by the conventional methods**	**a2, b1, b2, b3, c1, c2**	– Analytical design methods,, – dead beat response design methods, – example problems and solutions.	**1**	**2**
11	**State Space Analysis**	**a2, b1, b2, b3, c1, c2**	– state space representation of discrete-time control systems, – solving the discrete-time state space equations, – design example problems and solutions.	**1**	**2**
12	**Pole placement and observer design (modern design methods)**	**a2, b1, b2, b3, c1, c2, d1**	– Controllability, observability, – useful transformations in state space analysis, – design example problems and solutions.	**1**	**2**
13	**Pole placement and observer design (modern design methods)**	**a2, b1, b2, b3, c1, c2, d1**	– Pole placement design method, – example problems and solutions..	**1**	**2**
14	**Pole placement and observer design (modern design methods)**	**a2, b1, b2, b3, c1, c2, d1**	– observer design method, – example problems and solutions..	**1**	**2**
15	**Pole placement and observer design (modern design methods)**	**a2, b1, b2, b3, c1, c2, d1**	– Servo-controller design method, – example problems and	**1**	**2**

			solutions..		
16	**Final Theoretical Exam**	**a1, a2, b1, b2, b3, c1, c2**	– All Topics	**1**	**2**
Number of Weeks /and Units Per Semester				**16**	**32**

تعليق عليه [l12]: 14 & 28

تعليق عليه [l13]: يتم حذف الاختبارين النصفي والنهائي من المحتوي ويضافان فقط لخطة المقرر بحيث يصبح هنا عدد الأسابيع 14 وعدد الساعات 28

B - Practical Aspect: (if any)

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	**Introduction of digital control systems with matlab software.**	**1**	**2**	a1, a2
2	**Discrete-time control systems simulation and Simulink.**	**1**	**2**	a1, a2, b1, b2
3	**Discrete-time control systems simulation and Simulink.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
4	**Time-domain digital controller emulation.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
5	**Frequency-domain digital controller emulation.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
6	**Sampling, aliasing, zero-order hold (simulink).**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
7	**Midterm Practical Exam**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2
8	**Discrete-time plant modeling.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
9	**Root-locus, frequency response design methods for digital controllers.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
10	**Numerical optimal PID digital controller design in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1

11	**State-space digital controllers design in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
12	**State-space digital controllers design in matlab program.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
13	**Introduction to arduino IDE.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
14	**Implementation the digital controller with microcontroller by using the mikroc and proteus simulation software.**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2, d1
15	**Final Practical Exam**	**1**	**2**	a1, a2, b1, b2, b3, c1, c2
Number of Weeks /and Units Per Semester			**15**	**30**

تعليق عليه [l14]: 14 & 28

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Exercises and home works,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Workshops practices,
- Directed self- study,
- Problem based learning,
- Team work (cooperative learning),
- Field visits/training,
- Mini/major project.

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Oral exams,
- Short reports,
- Lab\Project report
- Practical lab performance assessment,
- Coursework activities assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Problems, and advance problems, and computer problems of the Chapter 2	a1, a2	2	6
2	Problems, and advance problems, and computer problems of the Chapter 3	a1, a2	3	6
3	Problems, and advance problems, and computer problems of the Chapter 4	a1, a2, b1, b2, b3	5	6
4	Problems, and advance problems, and computer problems of the Chapter 5	a1, a2, b1, b2, b3	9	6
5	Problems, and advance problems, and computer problems of the Chapter 6	a1, a2, b1, b2, b3, c1, c2	10	6
Total				30

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	**Assignments**	15	30	15%	a1, a2, b1, b2, b3, c1, c2
2	**Quiz 1**	6	10	5%	a1, a2, b1, b2, b3
3	**Midterm Theoretical Exam**	8	30	15%	a1, a2, b1, b2, b3
4	**Midterm Theoretical Exam**	9	20	10%	a1, a2, b1, b2, b3
5	**Quiz 2**	12	10	5%	a1, a2, b1, b2, b3, c1, c2
6	**Final Practical Exam**	15	30	15%	a1, a2, b1, b2, b3, c1, c2
7	**Final Theoretical Exam**	16	70	35%	a1, a2, b1, b2, b3, c1, c2
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- Katsuhiko Ogata, 2010, **Discrete-time control systems**, 2nd Edition, Prentice Hall.
2- Dogan Ibrahim, 2006, **microcontroller based applied a digital controller**, 1st Edition, john wiley & sons Inc.,

2- Essential References.

1- M. Sam Fadali, 2009, **Digital control systems analysis and design**, 1st Edition, Elsevier Inc.

2- FARIDGOLNARAGHI, BENJAMINC.KUO, 2010, **Automatic Control Systems**, ninth Edition, John Wiley & Sons, Inc.

3- Electronic Materials and Web Sites *etc*.

Websites:

1- National Instruments
https://learn.ni.com/teach/resources/1221/digital-control

2- The National Program on Technology Enhanced Learning (NPTEL), Automatic Control
https://nptel.ac.in/courses/112/107/112107240/

Journals:

3- IEEE Transactions on control systems technology: Peer reviewed academic journal..
https://www.ieeexplore.ieee.org/xpl

4- International Journal of control, automation and systems: The leading peer reviewed academic journal
. https://www.springer.com/Journal

Other Web Sources:

5- MIT Open Course Ware , Analysis and Design of Digital Control Systems
https://ocw.mit.edu/courses/mechanical-engineering/2-171-analysis-and-design-of-digital-control-systems-fall-2006/

6- Purdue University | Purdue Online Learning, College of Engineering, Digital Control
https://engineering.purdue.edu/ProEd/courses/digital-control

X. Course Policies:

1 **Class Attendance:**

A student should attend not less than 75 % of total hours of the subject; otherwise he/she 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 a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be

	required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she 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:** In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
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 proofed a plagiarism of a student, he/she 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 or according to the university roles.
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 might be given directly to students using soft or hard copy.

University of Sana'a
Faculty of Engineering
Department: Biomedical Engineering
Title of the Program: Biomedical Engineering

Template for Course Plan (Syllabus)

Digital Control Systems- BE352

I. Course Identification and General Information:					
1	**Course Title:**	Digital Control Systems			
2	**Course Code & Number:**	BE352			
3	**Credit Hours:**	**Credit Hours**	**Theory Hours**		**Lab. Hours**
			Lecture	**Exercise**	
		4	2	2	2
4	**Study Level/ Semester at which this Course is offered:**	4^{th} Level / 1^{st} Semester			
5	**Pre –Requisite (if any):**	Analog Control Systems (BE251)			
6	**Co –Requisite (if any):**	Microprocessor and Microcontrollers (BE353).			
7	**Program (s) in which the Course is Offered:**	Bachelor of Biomedical Engineering			
8	**Language of Teaching the Course:**	English			
9	**Location of Teaching the Course:**	Faculty of Engineering			
10	**Prepared by:**	Dr. Mohammed Al-Olofi			
11	**Reviewed by:**	Dr. Waleed Al-talabi			
12	**Date of Approval:**				

II. Course Description:

The Digital Control Systems course aims to give the student knowledge of the basic concepts and Theories of modeling, development, analysis, design and implement of modern and digital control

systems. This course includes the basic principles of digital control systems, quantization and quantization errors, data acquisitions, Z-transform and its applications to solve difference equations, Z plane analysis for discrete time control systems, impulse sampling, pulse transfer function, PID digital controllers realization and implementation, mapping between continuous –time control systems and discrete-time control systems, stability analysis, transient and steady state response, conventional and modern design methods of digital control systems, root-locus and bode plot design methods, analytical design methods, state space representation, controllability, observability, and servo-controllers. The practical part allows students to practice different digital control approaches studied in theoretical classes.

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)

A. Knowledge and Understanding: Upon successful completion of the course, students will be able to:	
a1	Understand the concepts, theories, and mathematical modeling of Digital systems in pulse transfer function model and state variable model.
a2	Explain how different analysis techniques are used to determine the specifications of digital control systems, and common design methods for design a digital controllers.
B. Intellectual Skills: Upon successful completion of the course, students will be able to:	
b1	Apply common conventional and modern engineering methods to model, analyze, and organize the digital biomedical systems.
b2	Analysis, and evaluate the biomedical engineering systems using the modern control engineering tools, then select a suitable digital controller for biomedical systems.
b3	Design the digital controllers, and others components of the medical devices by using the control system design methods.
C. Professional and Practical Skills: Upon successful completion of the course, students will be able to:	
c1	Use the modern engineering tools, and analytical techniques to evaluate performance

تعليق عليه [l15]: صحح الفعل

تعليق عليه [l16]: غير الفعل

تعليق عليه [l17]: احذف حد الفعلين

تعليق عليه [l18]: غير الفعل

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)	
	characteristics of different types of plant and process, and applying the knowledge to design, and implement a digital control systems.
c2	Conduct appropriate experimentation related to a digital control systems, and Locate different type of digital controllers used in real medical equipment.
D. Transferable Skills: Upon successful completion of the course, students will be able to:	
d1	Lead, and work productively as an individual and as a member of a team / multi-disciplinary team

تعليق عليه [l19]: احذف أحد الفعلين

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	**Introduction to discrete- time control systems**	– Introduction of digital control systems, – types of digital control systems, quantization methods, – data acquisition.	1	2
2	**The Z-Transform**	– Introduction, – Z-transform, Z-transform of elementary function, – properties and theorems of z-transform, – Inverse Z-transform, – solve the difference equations of digital control systems, – example problems and solutions.	1	2

تعليق عليه [l20]: المطلوب تحديد رقم الأسبوع الذي ستنفذ فيه المحاضرة وليس عدد الأسابيع:
W1-W2-W3….W16

تعليق عليه [I20]: المطلوب تحديد رقم الأسبوع الذي ستنفذ فيه المحاضرة وليس عدد الأسابيع:
W1-W2-W3….W16

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
3	**The Z-plane analysis of discrete-time control systems**	– Impulse sampling and data holding, – components of digital control systems, – pulse transfer function, – reduction block diagram in digital control systems, – example problems and solutions.	1	2
4	**The Z-plane analysis of discrete-time control systems**	– PID digital controllers, – realization and implementation of digital controllers, – microcontroller implementation to digital controllers, – select the sampling interval, – example problems and solutions.	1	2
5	**Design of discrete-time control systems by the conventional methods**	– Introduction to design methods, – mapping between s-plane and z-plane, – example problems and solutions.	1	2
6	**Design of discrete-time control systems by the**	– Transient and steady state response analysis of feedback digital control systems,	1	2

تعليق عليه [I20]: المطلوب تحديد رقم الأسبوع الذي ستنفذ فيه المحاضرة وليس عدد الأسابيع:
W1-W2-W3….W16

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
	conventional methods	– example problems and solutions..		
7	**Design of discrete-time control systems by the conventional methods**	– Introduction to conventional design methods, – the root locus method, – design based the root locus method, – example problems and solutions	**1**	**2**
8	**Mid-Term Theoretical Exam**	– Previous Topics	**1**	**2**
9	**Design of discrete-time control systems by the conventional methods**	– Frequency response methods, – bode plot, – design based on the Frequency response methods, – example problems and solutions.	**1**	**2**
10	**Design of discrete-time control systems by the conventional methods**	– Analytical design methods,, – dead beat response design methods, – example problems and solutions.	**1**	**2**
11	**State Space Analysis**	– state space representation of discrete-time control systems, – solving the discrete-time state	**1**	**2**

تعليق عليه [l20]: المطلوب تحديد رقم الأسبوع الذي ستنفذ فيه المحاضرة وليس عدد الأسابيع:
W1-W2-W3….W16

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		space equations, – design example problems and solutions.		
12	**Pole placement and observer design (modern design methods)**	– Controllability, observability, – useful transformations in state space analysis, – design example problems and solutions.	**1**	**2**
13	**Pole placement and observer design (modern design methods)**	– Pole placement design method, – example problems and solutions..	**1**	**2**
14	**Pole placement and observer design (modern design methods)**	– observer design method, – example problems and solutions..	**1**	**2**
15	**Pole placement and observer design (modern design methods)**	– Servo-controller design method, – example problems and solutions..	**1**	**2**
16	**Final Theoretical Exam**	– All Topics	**1**	**2**
Number of Weeks /and Units Per Semester			**16**	**32**

تعليق عليه [l21]: المطلوب تحديد رقم الأسبوع الذي ستنفذ فيه المحاضرة وليس عدد الأسابيع:
W1-W2-W3….W16

B. Case Studies and Practical Aspect:			
No.	**Tasks/ Experiments**	**Number of Weeks**	**Contact Hours**
1	Introduction of digital control systems with matlab software.	1	2
2	Discrete-time control systems simulation and Simulink.	1	2
3	Discrete-time control systems simulation and Simulink.	1	2
4	Time-domain digital controller emulation.	1	2
5	Frequency-domain digital controller emulation.	1	2
6	Sampling, aliasing, zero-order hold (simulink).	1	2
7	Midterm Practical Exam	1	2
8	Discrete-time plant modeling.	1	2
9	Root-locus, frequency response design methods for digital controllers.	1	2
10	Numerical optimal PID digital controller design in matlab program.	1	2
11	State-space digital controllers design in matlab program.	1	2
12	State-space digital controllers design in matlab program.	1	2
13	Introduction to arduino IDE.	1	2
14	Implementation the digital controller with microcontroller by using the mikroc and proteus simulation software.	1	2
15	Final Practical Exam	1	2
Number of Weeks /and Units Per Semester		**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Tutorials,
- Videos demonstrations,
- Presentation/seminar,
- Interactive class discussions,
- Case studies,
- Exercises and home works,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Workshops practices,
- Directed self- study,
- Problem based learning,
- Team work (cooperative learning),
- Field visits/training,
- Mini/major project.

VI. Assessment Methods of the Course:

- Written tests (mid and final terms and quizzes),
- Oral exams,
- Short reports,
- Lab\Project report
- Practical lab performance assessment,
- Coursework activities assessment,
- Home works and assignments,
- Presentations.

VII. Assignments:

No.	Assignments	Week Due	Mark
1	Problems, and advance problems, and computer problems of the Chapter 2	2	6
2	Problems, and advance problems, and computer problems of the Chapter 3	3	6
3	Problems, and advance problems, and computer problems of the Chapter 4	5	6
4	Problems, and advance problems, and computer problems of the Chapter 5	9	6
5	Problems, and advance problems, and computer problems of the Chapter 6	10	6
Total			**30**

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

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1	**Assignments**	15	30	15%
2	**Quiz 1**	6	10	5%
3	**Midterm Theoretical Exam**	8	30	15%
4	**Midterm Theoretical Exam**	9	20	10%
5	**Quiz 2**	12	10	5%
6	**Final Practical Exam**	15	30	15%
7	**Final Theoretical Exam**	16	70	35%
Total			**200**	**100%**

IX. Learning Resources:

- *Written in the following order:*

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

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

1- Katsuhiko Ogata, 2010, **Discrete-time control systems**, 2nd Edition, Prentice Hall.

2- Dogan Ibrahim, 2006, **microcontroller based applied a digital controller**, 1st Edition, john wiley & sons Inc.,

2- Essential References:

3- M. Sam Fadali, 2009, **Digital control systems analysis and design**, 1st Edition, Elsevier Inc.

4- FARIDGOLNARAGHI, BENJAMINC.KUO, 2010, **Automatic Control Systems**, ninth Edition, John Wiley & Sons, Inc.

3- Electronic Materials and Web Sites etc.:

Websites:

1- National Instruments
https://learn.ni.com/teach/resources/1221/digital-control

2- The National Program on Technology Enhanced Learning (NPTEL), Automatic Control
https://nptel.ac.in/courses/112/107/112107240/

Journals:

3- IEEE Transactions on control systems technology: Peer reviewed academic journal..
https://www.ieeexplore.ieee.org/xpl

4- International Journal of control, automation and systems: The leading peer reviewed academic journal
. https://www.springer.com/Journal

Other Web Sources:

5- MIT Open Course Ware , Analysis and Design of Digital Control Systems
https://ocw.mit.edu/courses/mechanical-engineering/2-171-analysis-and-design-of-digital-control-systems-fall-2006/

6- Purdue University | Purdue Online Learning, College of Engineering, Digital Control

IX. Learning Resources:

https://engineering.purdue.edu/ProEd/courses/digital-control

X. Course Policies:

1	**Class Attendance:** A student should attend not less than 75 % of total hours of the subject; otherwise he/she 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 a proof statement from university Clinic. If the absent is more than 25% of a course total contact hours, student will be required to retake the entire course again.
2	**Tardy:** For late in attending the class, the student will be initially notified. If he repeated lateness in attending class, he/she will be considered as absent.
3	**Exam Attendance/Punctuality:** A student should attend the exam on time. He/she 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:** In general one assignment is given to the students after each chapter; the student has to submit all the assignments for checking on time, mostly one week after given the assignment.
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 proofed a plagiarism of a student, he/she 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 or according to the university roles.
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 might be given directly to students using soft or hard copy.