



Republic of Yemen

Ministry of Higher Education & Scientific Research
Council of Academic Accreditation & Quality



Assurance of Higher Education (CAQA)

21 September University for medical and Applied Science

Faculty of Engineering and Computer
Department of Biomedical Engineering
Program of Biomedical Engineering

Course Specification of Bioelectronics

Course Code. (07.12.725)

2024



T4: This Template is Developed and Approved by CAQA-Yemen, 2023

Prepared by:	Reviewed by:	Head of the Department:	Quality Unit:	Dean:
Dr. Awadh Al-Kubati	Dr. ----	Dr. Awadh Al-Kubati	Dr. Mohammed Al-shamahi	Dr. Abdulrahman Obaid

I. General Information:

1.	Course Title:	Bioelectronics				
2.	Course Code:	07.12.725				
3.	Credit Hours:	Credit Hours	Theory Contact Hours		Practical Contact Hours	
			Lecture	Tutorial /Seminar	Lab	Clinical
		3	3	--	--	--
4.	Level/ Semester at which this Course is offered:	4 th Level / 1 st Semester				
5.	Pre –Requisite (if any):	07.12.717				
6.	Co –Requisite (if any):	N/A				
7.	Program (s) in which the Course is Offered:	Bachelor of Biomedical Engineering				
8.	Language of Teaching the Course:	English/Arabic				
9.	Location of Teaching the Course:	Faculty of Medical Technology				
10.	Prepared by:	Dr. Awadh Al-Kubati				
11	Date and Number of Approval by Council:					

II. Course Description:

The Bioelectronics course aims to introduce students the application of electronics engineering principles and technologies to biology, medicine, and health science. The course covers the basic concepts of biosensors, amplifiers, basic op-amp circuits, electrical filters principles, biopotential amplifiers, types of amplifiers used in medical devices, biomedical signals amplifier. The course focuses on biomedical applications pertaining to the human body for diagnostics, therapeutics, and advanced in-vivo systems.

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III. Course Intended Learning Outcomes (CILOs) : Upon successful completion of the course, students will be able to:		Referenced PILOs	
A. Knowledge and Understanding:		I, P or M/A	
a1	Explain the theories and methods for solving bioelectrical circuits and solution concepts related to solving linear circuits.	I	A1 Explain the appropriate models, theories, mathematical foundations, and techniques related to biomedical engineering technology context.
a2	Know the basic theories and concepts in bioelectronic circuits.	I	A2 Clarify the biomedical devices maintenance principles and how these are important for solving biomedical devices and equipment's problems in health environment.
a3	Understand the methodology for amplification of bio-signal using bioelectronics circuits.	I	A4 Understand an examples of a biomedical engineering technology concept and methods related to maintenance, measurement techniques, programming, creative engineering solutions, analytical skills, applied to healthcare quality and problems of medical devices issues
B. Intellectual Skills:			
b1	Apply practical skills related to the application of bioelectronic circuits solution.	P	B4 Apply the principles of biomedical devices maintenance and its various methods to work professionally in biomedical engineering field.
b2	Analyze a bioelectronics circuit and using different methods to develop and improve the medical devices circuit.	P	B2 Analyze the impacts of problems related to the Biomedical equipments and its solution principles in a creative manner by using a systematic and analytical thinking methods.

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b3	Reconfigure theories and methods for amplification of bio-signals using the electronic tools and bioelectronic circuits.	P	B3	Assess the features of biomedical devices systems, engineering diagnostic skills, technological expertise, and analytical methods that related to identify and addressing of biomedical devices systems failures.
C. Professional and Practical Skills:				
c1	Differentiate between solutions in various bioelectronic circuit problems.	P	C1	Relate integrally knowledge of life science, biomedical engineering technology practice concepts, principles of engineering and techniques evaluation to solve problems relevant to biomedical engineering.
c2	Use the laboratory tools and various methods in designing, implementing, and testing of bioelectronic circuits.	P	C2	Evaluate an engineering technique, modern analytical tools and required computer programs to analyzing and solve the problems of medical devices
c3	Design and implementing bioelectronic circuits.	M	C3	Develop an engineering approach, engineering equipment, instruments to maintenance and conduct experiments, and present results in the biomedical engineering practice.
D. Transferable Skills:				
d1	Recognize the needs for, and engage in life-long self-learning.	M/A	D1	Pursue ongoing professional development and lifelong learning in the biomedical engineering filed.
I= Introduced, P=Practiced or M/A= Mastered/Advanced				

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

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	Course Intended Learning Outcomes	Teaching Strategies	Assessment Strategies
a1	Explain the theories and methods for solving bioelectrical circuits and solution concepts related to solving linear circuits.	<ul style="list-style-type: none"> ▪ Interactive lectures ▪ Discussions ▪ Self-learning ▪ Presentation 	<ul style="list-style-type: none"> ▪ Written tests (mid and final terms and quizzes), ▪ Home works and assignments, ▪ Presentations.
a2	Know the basic theories and concepts in bioelectronic circuits.		
a3	Understand the methodology for amplification of bio-signal using bioelectronics circuits.		

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

	Course Intended Learning Outcomes	Teaching Strategies	Assessment Strategies
b1	Apply practical skills related to the application of bioelectronic circuits solution.	<ul style="list-style-type: none"> ▪ Interactive lectures ▪ Exercises & examples ▪ Interactive class discussions ▪ Presentation/seminar, ▪ Laboratory/Practical experiments-based session, ▪ Computer laboratory-based sessions ▪ Team work (cooperative learning), ▪ Mini/major project. 	<ul style="list-style-type: none"> ▪ Written tests (mid and final terms and quizzes), ▪ Lab\Project report ▪ Practical lab performance assessment, ▪ Home works and assignments, ▪ Presentations.
b2	Analyze a bioelectronics circuit and using different methods to develop and improve the medical devices circuit.		
b3	Reconfigure theories and methods for amplification of bio-signals using the electronic tools and bioelectronic circuits.		

(C) Alignment of Course Intended Learning Outcomes (Professional and Practical Skills) to Teaching Strategies and Assessment Methods:

	Course Intended Learning Outcomes	Teaching Strategies	Assessment Strategies
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c1	Differentiate between solutions in various bioelectronic circuit problems.	<ul style="list-style-type: none"> - Interactive lectures & examples, - Presentation/seminar, - Interactive class discussions, - Laboratory/Practical experiments-based session, - Computer laboratory-based sessions, - Team work (cooperative learning), - Mini/major project. - Directed self- study. 	<ul style="list-style-type: none"> - Written tests (mid and final terms and quizzes), - Lab\Project report - Practical lab performance assessment, - Home works and assignments. - Presentations.
c2	Use the laboratory tools and various methods in designing, implementing, and testing of bioelectronic circuits.		
c3	Design and implementing bioelectronic circuits.		
(D) Alignment of Course Intended Learning Outcomes (Transferable Skills) to Teaching Strategies and Assessment Methods:			
	Course Intended Learning Outcomes	Teaching Strategies	Assessment Strategies
d1	Recognize the needs for, and engage in life-long self-learning.	<ul style="list-style-type: none"> - Team-based projects presentation - Interactive class discussions 	<ul style="list-style-type: none"> - Home works and assignments, - Presentations.

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	Introduction	<ul style="list-style-type: none"> - Introduction to the course. - Course outlines. - Project description. - Introduction to bioelectronics. 	1	2	-
2	Basics concepts of amplifiers	<ul style="list-style-type: none"> - The operational amplifier - Op-amp parameters - Negative feedback 	1	2	a1, b1

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
		<ul style="list-style-type: none"> - Noninverting amplifier - Voltage-follower - Inverting amplifier - Effects of negative feedback on op-amp impedances 			
3	Basic op-amp circuits	<ul style="list-style-type: none"> - Comparators - Zero-level detection - Nonzero-level detection - Effects of input noise on comparator operation - Reducing noise effects with hysteresis. - Operation of a comparator with hysteresis - Analog-to-digital (a/d) conversion 	1	2	a1, b1
4	Summing amplifiers, Integrators, and differentiators	<ul style="list-style-type: none"> - Summing amplifier with n inputs - Summing Amplifier with Gain Greater Than Unity - Averaging Amplifier - Scaling Adder - Digital -to- Analog (D/A) Conversion - The op-amp integrator - The op-amp differentiator - A differentiator with a ramp input 	1	2	a1, b1
5	Filters and basic filters	<ul style="list-style-type: none"> - Active filters - Low-pass filter response 	2	4	a1, a2, b1, b2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
	responses	<ul style="list-style-type: none"> - High-pass filter response - Band-pass filter response - Quality factor and the damping factor - Band-stop filter response - Butterworth, Chebyshev and Bessel Characteristics - Damping factors - Critical frequency and roll-off rate - Cascaded filters - Butterworth characteristic 			
6	Mid-term Exam	<ul style="list-style-type: none"> - All previous topics 	1	2	a1, b1,b2
7	Active low-pass, high-pass, and band-pass filters	<ul style="list-style-type: none"> - A single-pole filter - The sallenkey low-pass filter - Cascaded low-pass filters - Four-pole configuration - A single-pole filter - High-pass filter response - The sallenkey high-pass filter - Cascading high-pass filters - Cascaded low-pass and high-pass filters - Multiple-feedback band-pass filter 	2	4	a2, a3, b2, b3
8	Biopotential amplifiers	<p>Types of Amplifiers used in medical devices:</p> <ul style="list-style-type: none"> - Instrumentation amplifiers 	1	2	a2, b3, c1, c2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
		<ul style="list-style-type: none"> - Isolation amplifiers - Chopper stabilizer amplifiers – Input guarding 			
9	Biomedical signals amplification	<ul style="list-style-type: none"> - ECG cardiac conduction system - Einthoven triangle and leads - Electrocardiographic signal - Electrocardiograph. Acquisition for ECG signals - Block diagram of an ECG system - Amplification - ECG acquisition systems filters - Differential amplifier - Cardiographer amplifier - Detection of the electrode's false contacts - Zero resetting – Amplifier protection 	1	2	a2, b2, c1, c3
10	Electrical isolation in bioelectrical devices	<ul style="list-style-type: none"> - Optical isolation - Magnetic isolation - Electrical insulation of the ECG amplifier - Optical insulation method - Description of electrical circuit for optical insulation method - Power supply insulation method – Description of electrical circuit for power supply insulation 	1	2	a2, b3, c2, c3

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
11	Auxiliary circuits of a bio-signals acquisition systems	<ul style="list-style-type: none"> - Lead – fail detection circuit description - Zero resetting of the wave-forms - Baseline restoration - Others Biomedical signals amplification 	1	2	a3, c2
12	Project Presentation	– Student’s presentations.	14 th	2	d1
13	Final Practical Exam	– All practical topics.	1	2	b1, b2, b3, c1, c2, c3
14	Final Theoretical Exam	– All topics.	1	2	a1, a2, a3, b1, b2, b3
Number of Weeks /and Units Per Semester			16	32	

B. Practical Aspect (Lab/Clinical) (if any):

No.	Tasks/ Experiments	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	<ul style="list-style-type: none"> - Voltage follower circuit simulation - Inverting amplifier circuit simulation - Non- inverting amplifier circuit simulation 	1	2	c1, c2
2	<ul style="list-style-type: none"> - Summing amplifier circuit simulation - Difference amplifier circuit simulation - Zero crossing detector circuit simulation - Schmitt trigger circuit simulation 	3	6	b3, c1, c2, c3

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No.	Tasks/ Experiments	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
	<ul style="list-style-type: none"> ▪ Differentiator circuit simulation ▪ Integrator circuit simulation ▪ Symmetrical and asymmetrical astable multivibrators using op amp circuit simulation ▪ Monostable multivibrator using op amp circuit simulation ▪ Wien bridge oscillator using op amp circuit simulation ▪ Astable and monostable multivibrator using ic 555 circuit simulation 			
3	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Differential amplifier circuit simulation ▪ Instrumentation amplifier circuit simulation 	1	2	b1, b3, c1
4	<ul style="list-style-type: none"> ▪ Integrator circuit simulation ▪ Differentiator circuit simulation ▪ Non Idealities of the Opamp circuit simulation ▪ Finite Gain Bandwidth (GBW) Product circuit simulation ▪ Slew Rate circuit simulation 	2	4	b2, b3, c1, c2
5	<ul style="list-style-type: none"> ▪ Lossy integrator configuration circuit simulation ▪ First order high-pass filter circuit simulation ▪ Finite Gain Bandwidth Limitations in Opamps circuit simulation ▪ Slew Rate Limitations in Opamps circuit simulation 	2	4	b1, b2, c1, c2
6	<ul style="list-style-type: none"> ▪ ECG simulator circuit diagram 	1	2	b1, b3, c1

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No.	Tasks/ Experiments	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
7	▪ ECG System implementation using arduino	2	4	b3, c1, c2, c3, d1
8	▪ Project Work Presentation	1	2	b2, c3, d1
9	▪ Final Practical Exam	1	2	b1, b2, b3, c1, c2, c3, d1
Number of Weeks /and Units Per Semester		14	28	

C. Tutorial Aspect (if any):

No.	Tutorial	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
1	None			
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

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No.	Tutorial	Number of Weeks	Contact Hours	Learning Outcomes (CILOs)
13				
14				
Number of Weeks /and Units Per Semester				

VII. Assignments:

No.	Assignments	Week Due	Mark	Aligned CILOs (symbols)
1	Assignment 1: Implementation circuit for signal amplification	Week 6	10	a1, b1, c2
2	Assignment 2: Implementation circuit for signal Filtration	Week 9	10	a2, b2, d1
3	Assignment 3: Implementation circuit Biomedical signal Amplification and Filtration Procedures	Week 12	10	c1, c2, d1
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	Project/ Assignments and Quizzes	Weeks 4, 8, 12	10	20%	a1- d1
2	Mid-Term Theoretical Exam	Week 8	10	10%	a1, b1, b2
3	Final Practical Exam and Practical Experiments	Week 15	30	30%	b1, b2, b3, c1, c2, c3, d1
4	Final Theoretical Exam	Week 16	50	50%	a1, a2, a3, b1, b2, b3

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No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
Total			100%	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. Lecture notes.
2. Nandini K. Jog., electronics in medicine and biomedical instrumentation, Second Edition, PHI Learning Private Limited, 2013

2- Essential References:

1. Michael R. Neuman, Robert B. Northrop. p., "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press LLC, 2004.
2. Nokes L., Jennings D., Flint T. "Introduction to Medical Electronics Applications". Edward Arnold, a division of Hodder Headline PLC (1995).
3. Kunal Pal, Heinz-Bernhard Kraatz, Anwasha Khasnobish, Sandip Bag, Indranil Banerjee, Usha Kuruganti, 2019, "Bioelectronics and Medical Devices: From Materials to Devices—Fabrication, Applications, and Reliability", UK, Elsevier Ltd.

3- Electronic Materials and Web Sites etc.:

Websites:

- 1- Our lab works at the interface of materials science, electronics, and neurobiology with the goal of advancing the understanding and treatment of disorders of the nervous system. <https://bioelectronics.mit.edu/>
- 2- We are an interdisciplinary group of scientists, engineers and clinicians interested in interfacing electronics with living systems. <https://bioelectronics.eng.cam.ac.uk/>

Journals:

1. Biosensors and Bioelectronics is the principal international journal devoted to research, design development and application of biosensors and bioelectronics. <https://www.journals.elsevier.com/biosensors-and-bioelectronics>
2. Journal of Biosensors and Bioelectronics (JBSBE) is an Open Access peer reviewed journal covers advancements in bio actuators, bioelectronics, biosensor applications, biosensor packaging and assembly, biosensors clinical validation, biosensors in drug delivery, chemical sensor, immune sensors, integrated nano scale devices and microfluidics biosensors. <https://www.hilarispublisher.com/biosensors-bioelectronics.html>

X. Course Policies: (Based on the Uniform Students' By law (2007))

1 Class Attendance:

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	Class Attendance is mandatory. A student is considered absent and shall be banned from taking the final exam if his/her absence exceeds 25% of total classes.
2	Tardiness: A student will be considered late if he/she is not in class after 10 minutes of the start time of class.
3	Exam Attendance/Punctuality: No student shall be allowed to the exam hall after 30 minutes of the start time, and shall not leave the hall before half of the exam time has passed.
4	Assignments & Projects: Assignments and projects must be submitted on time. Students who delay their assignments or projects shall lose the mark allocated for the same.
5	Cheating: Cheating is an act of fraud that results in the cancelation of the student's exam or assignment. If it takes place in a final exam, the penalties stipulated for in the Uniform Students' Bylaw (2007) shall apply.
6	Forgery and Impersonation: Forgery/Impersonation is an act of fraud that results in the cancelation of the student's exam, assignment or project. If it takes place in a final exam, the penalties stipulated for in the Uniform Students' Bylaw (2007) shall apply.
7	Other policies: The University official regulations in force will be strictly observed and students shall comply with all rules and regulations of the examination set by the Department, Faculty and University Administration.

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Faculty of Medical Technology

Department of Biomedical Engineering

Program of Biomedical Engineering

Course Plan (Syllabus) of Bioelectronics

Course Code. (07.12.7)

I. Information about Faculty Member Responsible for the Course:							
Name of Faculty Member:	Dr. Awadh Al-Kubati	Office Hours					
Location & Telephone No.:	21 September University of Medical and Applied Science 770807295						
E-mail:	dawadh@21umas.edu.ye	SAT	SUN	MON	TUE	WED	THU

2024/2025

II. Course Identification and General Information:

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11.	Course Title:	Bioelectronics				
12.	Course Code:	07.12.725				
13.	Credit Hours:	Credit Hours	Theory Contact Hours		Practical Contact Hours	
			Lecture	Tutorial /Seminar	Lab	Clinical
		3	3	--	--	--
14.	Level/ Semester at which this Course is offered:	4th Level / 1st Semester				
15.	Pre –Requisite (if any):	07.12.717				
16.	Co –Requisite (if any):	N/A				
17.	Program (s) in which the Course is Offered:	Bachelor of Biomedical Engineering				
18.	Language of Teaching the Course:	English/Arabic				
19.	Location of Teaching the Course:	Faculty of Medical Technology				
20.	Prepared by:	Dr. Awadh Al-Kubati				
11	Date and Number of Approval by Council:					

III. Course Description:

The Bioelectronics course aims to introduce students the application of electronics engineering principles and technologies to biology, medicine, and health science. The course covers the basic concepts of biosensors, amplifiers, basic op-amp circuits, electrical filters principles, biopotential amplifiers, types of amplifiers used in medical devices, biomedical signals amplifier. The course focuses on biomedical applications pertaining to the human body for diagnostics, therapeutics, and advanced in-vivo systems.

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IV. Course Intended Learning Outcomes (CILOs) :

Upon successful completion of the Course, student will be able to:

A. Knowledge and Understanding:	
a1	Explain the theories and methods for solving bioelectrical circuits and solution concepts related to solving linear circuits.
a2	Know the basic theories and concepts in bioelectronic circuits.
a3	Understand the methodology for amplification of bio-signal using bioelectronics circuits.
B. Intellectual Skills:	

A. Knowledge and Understanding:	
a1	Explain the theories and methods for solving bioelectrical circuits and solution concepts related to solving linear circuits.
a2	Know the basic theories and concepts in bioelectronic circuits.
a3	Understand the methodology for amplification of bio-signal using bioelectronics circuits.
B. Intellectual Skills:	
b1	Apply practical skills related to the application of bioelectronic circuits solution.
b2	Analyze a bioelectronics circuit and using different methods to develop and improve the medical devices circuit.
b3	Reconfigure theories and methods for amplification of bio-signals using the electronic tools and bioelectronic circuits.
C. Professional and Practical Skills:	
c1	Differentiate between solutions in various bioelectronic circuit problems.
c2	Use the laboratory tools and various methods in designing, implementing, and testing of bioelectronic circuits.
c3	Design and implementing bioelectronic circuits.

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		D · T r a n s f e r a b l e S k i l l s :
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d1	Recognize the needs for, and engage in life-long self-learning.
I= Introduced, P=Practiced or M/A= Mastered/Advanced	

A. Knowledge and Understanding:	
a1	Explain the theories and methods for solving bioelectrical circuits and solution concepts related to solving linear circuits.
a2	Know the basic theories and concepts in bioelectronic circuits.
a3	Understand the methodology for amplification of bio-signal using bioelectronics circuits.

V. Course Contents:

A. Theoretical Aspect:

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	Introduction	<ul style="list-style-type: none"> - Introduction to the course. - Course outlines. - Project description. - Introduction to bioelectronics. 	1	2
2	Basics concepts of amplifiers	<ul style="list-style-type: none"> - The operational amplifier - Op-amp parameters - Negative feedback - Noninverting amplifier - Voltage-follower - Inverting amplifier - Effects of negative feedback on op-amp impedances 	1	2
3	Basic op-amp circuits	<ul style="list-style-type: none"> - Comparators - Zero-level detection - Nonzero-level detection - Effects of input noise on comparator operation - Reducing noise effects with hysteresis. - Operation of a comparator with hysteresis - Analog-to-digital (a/d) conversion 	1	2
4	Summing amplifiers, Integrators, and differentiators	<ul style="list-style-type: none"> - Summing amplifier with n inputs - Summing Amplifier with Gain Greater Than Unity - Averaging Amplifier - Scaling Adder 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Digital -to- Analog (D/A) Conversion - The op-amp integrator - The op-amp differentiator - A differentiator with a ramp input 		
5	Filters and basic filters responses	<ul style="list-style-type: none"> - Active filters - Low-pass filter response - High-pass filter response - Band-pass filter response - Quality factor and the damping factor - Band-stop filter response - Butterworth, Chebyshev and Bessel Characteristics - Damping factors - Critical frequency and roll-off rate - Cascaded filters - Butterworth characteristic 	2	4
6	Mid-term Exam	<ul style="list-style-type: none"> - All previous topics 	1	2
7	Active low-pass, high-pass, and band-pass filters	<ul style="list-style-type: none"> - A single-pole filter - The sallenkey low-pass filter - Cascaded low-pass filters - Four-pole configuration - A single-pole filter - High-pass filter response - The sallenkey high-pass filter - Cascading high-pass filters 	2	4

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Cascaded low-pass and high-pass filters - Multiple-feedback band-pass filter 		
8	Biopotential amplifiers	Types of Amplifiers used in medical devices: <ul style="list-style-type: none"> - Instrumentation amplifiers - Isolation amplifiers - Chopper stabilizer amplifiers - Input guarding 	1	2
9	Biomedical signals amplification	<ul style="list-style-type: none"> - ECG cardiac conduction system - Einthoven triangle and leads - Electrocardiographic signal - Electrocardiograph. Acquisition for ECG signals - Block diagram of an ECG system - Amplification - ECG acquisition systems filters - Differential amplifier - Cardiographer amplifier - Detection of the electrode's false contacts - Zero resetting - Amplifier protection 	1	2
10	Electrical isolation in bioelectrical devices	<ul style="list-style-type: none"> - Optical isolation - Magnetic isolation - Electrical insulation of the ECG amplifier - Optical insulation method 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Description of electrical circuit for optical insolation method - Power supply insolation method - Description of electrical circuit for power supply insolation 		
11	Auxiliary circuits of a bio-signals acquisition systems	<ul style="list-style-type: none"> - Lead – fail detection circuit description - Zero resetting of the wave-forms - Baseline restoration - Others Biomedical signals amplification 	1	2
12	Project Presentation	<ul style="list-style-type: none"> - Student's presentations. 	14 th	2
13	Final Practical Exam	<ul style="list-style-type: none"> - All practical topics. 	1	2
14	Final Theoretical Exam	<ul style="list-style-type: none"> - All topics. 	1	2
Number of Weeks /and Units Per Semester			16	32

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	Introduction	<ul style="list-style-type: none"> - Introduction to the course. - Course outlines. - Project description. - Introduction to bioelectronics. 	1	2
2	Basics concepts of amplifiers	<ul style="list-style-type: none"> - The operational amplifier - Op-amp parameters - Negative feedback 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Noninverting amplifier - Voltage-follower - Inverting amplifier - Effects of negative feedback on op-amp impedances 		
3	Basic op-amp circuits	<ul style="list-style-type: none"> - Comparators - Zero-level detection - Nonzero-level detection - Effects of input noise on comparator operation - Reducing noise effects with hysteresis. - Operation of a comparator with hysteresis - Analog-to-digital (a/d) conversion 	1	2
4	Summing amplifiers, Integrators, and differentiators	<ul style="list-style-type: none"> - Summing amplifier with n inputs - Summing Amplifier with Gain Greater Than Unity - Averaging Amplifier - Scaling Adder - Digital -to- Analog (D/A) Conversion - The op-amp integrator - The op-amp differentiator - A differentiator with a ramp input 	1	2
5	Filters and basic filters responses	<ul style="list-style-type: none"> - Active filters - Low-pass filter response - High-pass filter response 	2	4

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Band-pass filter response - Quality factor and the damping factor - Band-stop filter response - Butterworth, Chebyshev and Bessel Characteristics - Damping factors - Critical frequency and roll-off rate - Cascaded filters - Butterworth characteristic 		
6	Mid-term Exam	<ul style="list-style-type: none"> - All previous topics 	1	2
7	Active low-pass, high-pass, and band-pass filters	<ul style="list-style-type: none"> - A single-pole filter - The sallenkey low-pass filter - Cascaded low-pass filters - Four-pole configuration - A single-pole filter - High-pass filter response - The sallenkey high-pass filter - Cascading high-pass filters - Cascaded low-pass and high-pass filters - Multiple-feedback band-pass filter 	2	4
8	Biopotential amplifiers	<p>Types of Amplifiers used in medical devices:</p> <ul style="list-style-type: none"> - Instrumentation amplifiers - Isolation amplifiers - Chopper stabilizer amplifiers - Input guarding 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
9	Biomedical signals amplification	<ul style="list-style-type: none"> - ECG cardiac conduction system - Einthoven triangle and leads - Electrocardiographic signal - Electrocardiograph. Acquisition for ECG signals - Block diagram of an ECG system - Amplification - ECG acquisition systems filters - Differential amplifier - Cardiographer amplifier - Detection of the electrode's false contacts - Zero resetting - Amplifier protection 	1	2
10	Electrical isolation in bioelectrical devices	<ul style="list-style-type: none"> - Optical isolation - Magnetic isolation - Electrical insulation of the ECG amplifier - Optical insulation method - Description of electrical circuit for optical insulation method - Power supply insulation method - Description of electrical circuit for power supply insulation 	1	2
11	Auxiliary circuits of a bio-signals acquisition	<ul style="list-style-type: none"> - Lead – fail detection circuit description - Zero resetting of the wave-forms 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
	systems	<ul style="list-style-type: none"> - Baseline restoration - Others Biomedical signals amplification 		
12	Project Presentation	<ul style="list-style-type: none"> - Student's presentations. 	14th	2
13	Final Practical Exam	<ul style="list-style-type: none"> - All practical topics. 	1	2
14	Final Theoretical Exam	<ul style="list-style-type: none"> - All topics. 	1	2
Number of Weeks /and Units Per Semester			16	32

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	Introduction	<ul style="list-style-type: none"> - Introduction to the course. - Course outlines. - Project description. - Introduction to bioelectronics. 	1	2
2	Basics concepts of amplifiers	<ul style="list-style-type: none"> - The operational amplifier - Op-amp parameters - Negative feedback - Noninverting amplifier - Voltage-follower - Inverting amplifier - Effects of negative feedback on op-amp impedances 	1	2
3	Basic op-amp circuits	<ul style="list-style-type: none"> - Comparators - Zero-level detection - Nonzero-level detection 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Effects of input noise on comparator operation - Reducing noise effects with hysteresis. - Operation of a comparator with hysteresis - Analog-to-digital (a/d) conversion 		
4	Summing amplifiers, Integrators, and differentiators	<ul style="list-style-type: none"> - Summing amplifier with n inputs - Summing Amplifier with Gain Greater Than Unity - Averaging Amplifier - Scaling Adder - Digital -to- Analog (D/A) Conversion - The op-amp integrator - The op-amp differentiator - A differentiator with a ramp input 	1	2
5	Filters and basic filters responses	<ul style="list-style-type: none"> - Active filters - Low-pass filter response - High-pass filter response - Band-pass filter response - Quality factor and the damping factor - Band-stop filter response - Butterworth, Chebyshev and Bessel Characteristics - Damping factors - Critical frequency and roll-off rate 	2	4

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - Cascaded filters - Butterworth characteristic 		
6	Mid-term Exam	<ul style="list-style-type: none"> - All previous topics 	1	2
7	Active low-pass, high-pass, and band-pass filters	<ul style="list-style-type: none"> - A single-pole filter - The sallenkey low-pass filter - Cascaded low-pass filters - Four-pole configuration - A single-pole filter - High-pass filter response - The sallenkey high-pass filter - Cascading high-pass filters - Cascaded low-pass and high-pass filters - Multiple-feedback band-pass filter 	2	4
8	Biopotential amplifiers	<p>Types of Amplifiers used in medical devices:</p> <ul style="list-style-type: none"> - Instrumentation amplifiers - Isolation amplifiers - Chopper stabilizer amplifiers - Input guarding 	1	2
9	Biomedical signals amplification	<ul style="list-style-type: none"> - ECG cardiac conduction system - Einthoven triangle and leads - Electrocardiographic signal - Electrocardiograph. Acquisition for ECG signals - Block diagram of an ECG system - Amplification 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		<ul style="list-style-type: none"> - ECG acquisition systems filters - Differential amplifier - Cardiographer amplifier - Detection of the electrode's false contacts - Zero resetting - Amplifier protection 		
10	Electrical isolation in bioelectrical devices	<ul style="list-style-type: none"> - Optical isolation - Magnetic isolation - Electrical insulation of the ECG amplifier - Optical insulation method - Description of electrical circuit for optical insulation method - Power supply insulation method - Description of electrical circuit for power supply insulation 	1	2
11	Auxiliary circuits of a bio-signals acquisition systems	<ul style="list-style-type: none"> - Lead – fail detection circuit description - Zero resetting of the wave-forms - Baseline restoration - Others Biomedical signals amplification 	1	2
12	Project Presentation	<ul style="list-style-type: none"> - Student's presentations. 	14 th	2
13	Final Practical Exam	<ul style="list-style-type: none"> - All practical topics. 	1	2
14	Final Theoretical	<ul style="list-style-type: none"> - All topics. 	1	2

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No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
	Exam			
Number of Weeks /and Units Per Semester			16	32

B. Case Studies and Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
1	<ul style="list-style-type: none"> ▪ Voltage follower circuit simulation ▪ Inverting amplifier circuit simulation ▪ Non- inverting amplifier circuit simulation 	1	2
2	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Difference amplifier circuit simulation ▪ Zero crossing detector circuit simulation ▪ Schmitt trigger circuit simulation ▪ Differentiator circuit simulation ▪ Integrator circuit simulation ▪ Symmetrical and asymmetrical astable multivibrators using op amp circuit simulation ▪ Monostable multivibrator using op amp circuit simulation ▪ Wien bridge oscillator using op amp circuit simulation ▪ Astable and monostable multivibrator using ic 555 circuit simulation 	3	6
3	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Differential amplifier circuit simulation ▪ Instrumentation amplifier circuit simulation 	1	2
4	<ul style="list-style-type: none"> ▪ Integrator circuit simulation 	2	4

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No.	Tasks/ Experiments	Number of Weeks	Contact Hours
	<ul style="list-style-type: none"> ▪ Differentiator circuit simulation ▪ Non Idealities of the Opamp circuit simulation ▪ Finite Gain Bandwidth (GBW) Product circuit simulation ▪ Slew Rate circuit simulation 		
5	<ul style="list-style-type: none"> ▪ Lossy integrator configuration circuit simulation ▪ First order high-pass filter circuit simulation ▪ Finite Gain Bandwidth Limitations in Opamps circuit simulation ▪ Slew Rate Limitations in Opamps circuit simulation 	2	4
6	<ul style="list-style-type: none"> ▪ ECG simulator circuit diagram 	1	2
7	<ul style="list-style-type: none"> ▪ ECG System implementation using arduino 	2	4
8	<ul style="list-style-type: none"> ▪ Project Work Presentation 	1	2
9	<ul style="list-style-type: none"> ▪ Final Practical Exam 	1	2
Number of Weeks /and Units Per Semester		14	28

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
1	<ul style="list-style-type: none"> ▪ Voltage follower circuit simulation ▪ Inverting amplifier circuit simulation ▪ Non- inverting amplifier circuit simulation 	1	2
2	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Difference amplifier circuit simulation ▪ Zero crossing detector circuit simulation ▪ Schmitt trigger circuit simulation ▪ Differentiator circuit simulation 	3	6

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No.	Tasks/ Experiments	Number of Weeks	Contact Hours
	<ul style="list-style-type: none"> ▪ Integrator circuit simulation ▪ Symmetrical and asymmetrical astable multivibrators using op amp circuit simulation ▪ Monostable multivibrator using op amp circuit simulation ▪ Wien bridge oscillator using op amp circuit simulation ▪ Astable and monostable multivibrator using ic 555 circuit simulation 		
3	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Differential amplifier circuit simulation ▪ Instrumentation amplifier circuit simulation 	1	2
4	<ul style="list-style-type: none"> ▪ Integrator circuit simulation ▪ Differentiator circuit simulation ▪ Non Idealities of the Opamp circuit simulation ▪ Finite Gain Bandwidth (GBW) Product circuit simulation ▪ Slew Rate circuit simulation 	2	4
5	<ul style="list-style-type: none"> ▪ Lossy integrator configuration circuit simulation ▪ First order high-pass filter circuit simulation ▪ Finite Gain Bandwidth Limitations in Opamps circuit simulation ▪ Slew Rate Limitations in Opamps circuit simulation 	2	4
6	<ul style="list-style-type: none"> ▪ ECG simulator circuit diagram 	1	2
7	<ul style="list-style-type: none"> ▪ ECG System implementation using arduino 	2	4
8	<ul style="list-style-type: none"> ▪ Project Work Presentation 	1	2

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No.	Tasks/ Experiments	Number of Weeks	Contact Hours
9	▪ Final Practical Exam	1	2
Number of Weeks /and Units Per Semester		14	28

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
1	<ul style="list-style-type: none"> ▪ Voltage follower circuit simulation ▪ Inverting amplifier circuit simulation ▪ Non- inverting amplifier circuit simulation 	1	2
2	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Difference amplifier circuit simulation ▪ Zero crossing detector circuit simulation ▪ Schmitt trigger circuit simulation ▪ Differentiator circuit simulation ▪ Integrator circuit simulation ▪ Symmetrical and asymmetrical astable multivibrators using op amp circuit simulation ▪ Monostable multivibrator using op amp circuit simulation ▪ Wien bridge oscillator using op amp circuit simulation ▪ Astable and monostable multivibrator using ic 555 circuit simulation 	3	6
3	<ul style="list-style-type: none"> ▪ Summing amplifier circuit simulation ▪ Differential amplifier circuit simulation ▪ Instrumentation amplifier circuit simulation 	1	2
4	<ul style="list-style-type: none"> ▪ Integrator circuit simulation ▪ Differentiator circuit simulation ▪ Non Idealities of the Opamp circuit simulation ▪ Finite Gain Bandwidth (GBW) Product circuit simulation 	2	4

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No.	Tasks/ Experiments	Number of Weeks	Contact Hours
	▪ Slew Rate circuit simulation		
5	<ul style="list-style-type: none"> ▪ Lossy integrator configuration circuit simulation ▪ First order high-pass filter circuit simulation ▪ Finite Gain Bandwidth Limitations in Opamps circuit simulation ▪ Slew Rate Limitations in Opamps circuit simulation 	2	4
6	▪ ECG simulator circuit diagram	1	2
7	▪ ECG System implementation using arduino	2	4
8	▪ Project Work Presentation	1	2
9	▪ Final Practical Exam	1	2
Number of Weeks /and Units Per Semester		14	28

C. Tutorial Aspect:

No.	Tutorial	Number of Weeks	Contact Hours
1	None		
2			
3			
4			
5			
6			
7			
8			
9			

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No.	Tutorial	Number of Weeks	Contact Hours
10			
11			
12			
13			
14			
Number of Weeks /and Units Per Semester			

VI. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Interactive class discussions
- Laboratory/Practical experiments-based session,
- Computer laboratory-based sessions
- Team work (cooperative learning),
- Mini/major project.
- Presentation/seminar,
- Directed self- study.
- Team-based projects presentation
- Interactive class discussions

VII. Assessment Methods of the Course:

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

VIII. Assignments:

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No.	Assignments	Week Due	Mark	Aligned CLOs (symbols)
1	Assignment 1: Implementation circuit for signal amplification	Week 6	10	a1 , b1 , c2
2	Assignment 2: Implementation circuit for signal Filtration	Week 9	10	a2 , b2 , d1
3	Assignment 3: Implementation circuit Biomedical signal Amplification and Filtration Procedures	Week 12	10	c1 , c2 , d1

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No.	Assignments	Week Due	Mark	Aligned CLOs (symbols)
Total			30	

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

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No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
1	Project/ Assignments and Quizzes	Weeks 4, 8, 12	10	20%	a1 - d1
2	Mid-Term Theoretical Exam	Week 8	10	10%	a1 , b1 , b2
3	Final Practical Exam and Practical Experiments	Week 15	30	30%	b1 , b2

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No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
					b3 c1 c2 c3 d1
4	Final Theoretical Exam	Week 16	50	50%	a1

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No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment	Aligned Course Learning Outcomes
					a2 , a3 , b1 , b2 , b3
Total			100%	100%	-

X. Learning Resources:

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<ul style="list-style-type: none"> • <i>Written in the following order:</i> Author, Year of publication, Title, Edition, Place of publication, Publisher.
1- Required Textbook(s) (maximum two):
<ol style="list-style-type: none"> 1. Lecture notes. 2. Nandini K. Jog., electronics in medicine and biomedical instrumentation, Second Edition, PHI Learning Private Limited, 2013
2- Essential References:
<ol style="list-style-type: none"> 1. Michael R. Neuman, Robert B. Northrop. p., "Analysis and Application of Analog Electronic Circuits to Biomedical Instrumentation", CRC Press LLC, 2004. 2. Nokes L., Jennings D., Flint T. "Introduction to Medical Electronics Applications". Edward Arnold, a division of Hodder Headline PLC (1995). 3. Kunal Pal, Heinz-Bernhard Kraatz, Anwasha Khasnobish, Sandip Bag, Indranil Banerjee, Usha Kuruganti, 2019, "Bioelectronics and Medical Devices: From Materials to Devices—Fabrication, Applications, and Reliability", UK, Elsevier Ltd.
3- Electronic Materials and Web Sites etc.:
<p>Websites:</p> <ol style="list-style-type: none"> 1. Our lab works at the interface of materials science, electronics, and neurobiology with the goal of advancing the understanding and treatment of disorders of the nervous system. https://bioelectronics.mit.edu/ 2. We are an interdisciplinary group of scientists, engineers and clinicians interested in interfacing electronics with living systems. https://bioelectronics.eng.cam.ac.uk/ <p>1-</p> <p>2- Journals:</p> <ol style="list-style-type: none"> 1. Biosensors and Bioelectronics is the principal international journal devoted to research, design development and application of biosensors and bioelectronics. https://www.journals.elsevier.com/biosensors-and-bioelectronics 2. Journal of Biosensors and Bioelectronics (JBSBE) is an Open Access peer reviewed journal covers advancements in bio actuators, bioelectronics, biosensor applications, biosensor packaging and assembly, biosensors clinical validation, biosensors in drug delivery, chemical sensor, immune sensors, integrated nano scale devices and microfluidics biosensors. https://www.hilarispublisher.com/biosensors-bioelectronics.html

XI. Course Policies: (Based on the Uniform Students' Bylaw (2007))

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X. Course Policies: (Based on the Uniform Students' By law (2007))

1	Class Attendance: Class Attendance is mandatory. A student is considered absent and shall be banned from taking the final exam if his/her absence exceeds 25% of total classes.
2	Tardiness: A student will be considered late if he/she is not in class after 10 minutes of the start time of class.
3	Exam Attendance/Punctuality: No student shall be allowed to the exam hall after 30 minutes of the start time, and shall not leave the hall before half of the exam time has passed.
4	Assignments & Projects: Assignments and projects must be submitted on time. Students who delay their assignments or projects shall lose the mark allocated for the same.
5	Cheating: Cheating is an act of fraud that results in the cancelation of the student's exam or assignment. If it takes place in a final exam, the penalties stipulated for in the Uniform Students' Bylaw (2007) shall apply.
6	Forgery and Impersonation: Forgery/Impersonation is an act of fraud that results in the cancelation of the student's exam, assignment or project. If it takes place in a final exam, the penalties stipulated for in the Uniform Students' Bylaw (2007) shall apply.
7	Other policies: The University official regulations in force will be strictly observed and students shall comply with all rules and regulations of the examination set by the Department, Faculty and University Administration.

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