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

Course Specification of Biomedical Sensors and Measurements

Course Code (BE224)

I. Course Identification and General Information:						
1	**Course Title:**	Biomedical Sensors and Measurements				
2	**Course Code & Number:**	BE224				
3	**Credit hours:**	C.H				TOTAL
		Th.	Seminar	Pr	Tr.	
		2	--	2	--	3
4	**Study level/ semester at which this course is offered:**	3rd Level / 1st Semester				
5	**Pre –requisite (if any):**	Engineering Physics (FR002), Physiology and Anatomy1,2 (BE161, BE162), General Biology (BE101), Electronics I (BE122),.				
6	**Co –requisite (if any):**	Electronics II (BE223)				
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. Waleed Al-talabi				
11	**Reviewed by:**	Dr. Mohammed Al-Olofi				
12	**Date of Approval:**					

II. Course Description:

The Biomedical Sensors & Measurements course aims to give the student knowledge of detection methods of bio-signal, and types of sensors used in measurement. As well as, theories and techniques for electronic measurements on physiological systems. The course will cover circuits and sensors used to measure bio-signals including cardiovascular system and measurements, respiratory system and measurements, patient monitoring and measurements, and electrical hazards, safety, measuring instruments and techniques will be discussed. The corequisite laboratory will focus on the practical implementation of electronic devices for biomedical measurements.

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	Demonstrate understanding of the principles of measurement systems, measurement error and uncertainty, basic concepts of a variety sensors and transducers.	A1 Describe and explain the underlying mathematical methods and theories; life scientific-principles; and engineering core concepts related to the Biomedical Engineering context.
a2	Illustrate understanding of the physiology of biomedical system which is very important with respect to design consideration. As well as, discussing the application of electronics in diagnostics and therapeutic area.	A2 Clarify the design principles and techniques and the engineering materials characteristics and how these are relevant to the developments and technologies in a biomedical systems context.
a3	Describe how different measurement techniques are used to determine the vital parameters of diagnostic importance, and common methods for	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

	converting a physical parameter into an electrical quantity and provide an engineering approach to develop biomedical measurement systems.	quality of life issues.
B. Cognitive/ Intellectual Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
b1	Design of basic measurement systems for biomedical applications, such as cardiovascular system and related measurements, respiratory system and related measurements, laboratorial instrumentation and patient monitor system with consideration of patient safety issues related to biomedical instrumentation.	B3 Design the biomedical systems or processes within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability and sustainability.
b2	Analyze, formulate and select suitable sensor comparing different standards and guidelines for the given industrial applications to make sensitive measurements of physical parameters, and predict correctly the expected performance of various sensors.	B5 Distinguish the main characteristics of biomedical systems, apply diagnostic skills and technical knowledge and perform failure analysis to these systems.
C. Professional and Practical Skills: Upon successful completion of the undergraduate Biomedical Engineering Program, the graduates will be able to:		
c1	Use the biostatistics, analytical techniques, and set up testing strategies to evaluate performance characteristics	C2 Use a wide range of analytical tools, techniques, IT, modern engineering tools, software packages and develop required computer programs to solve, modeling and

	of different types of sensors and transducers, and develop professional skills in acquiring and applying the knowledge to design, analyze, and realize a circuit of signal conditioning from these sensors.	analyzing Biomedical Engineering problems.
c2	Conduct appropriate experimentation related to sensors and transducers, and Locate different type of sensors used in real life applications and paraphrase their importance.	C3 Use computational facilities and techniques, measuring instruments, workshops and laboratory equipment to design and conduct 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	Demonstrate the ability to collaborative work as an effective member or leader of diverse teams, communicating effectively and operating within cross-disciplinary and cross-cultural contexts in the workplace, and the significance of time management in group work.	D1 Lead and motivate individuals, show capability to work in stressful environments and within constraints, collaborate effectively within multidisciplinary team.

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

Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
a1. Demonstrate understanding of the principles of measurement systems,	• Interactive lectures & examples, • Presentation/seminar, • Interactive class	• Written tests (mid and final terms and quizzes), • Home works and

measurement error and uncertainty, basic concepts of a variety sensors and transducers.	discussions, • Exercises and home works, • Directed self- study, • Problem based learning,	assignments.
a2. Illustrate understanding of the physiology of biomedical system which is very important with respect to design consideration. As well as, discussing the application of electronics in diagnostics and therapeutic area.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Directed self- study.	• Written tests (mid and final terms and quizzes), • Oral exams, • Home works and assignments, • Presentations.
a3. Describe how different measurement techniques are used to determine the vital parameters of diagnostic importance, and common methods for converting a physical parameter into an electrical quantity and provide an engineering approach to develop biomedical measurement systems.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Directed self- study.	• Written tests (mid and final terms and quizzes), • 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. Design of basic measurement systems for biomedical applications, such as cardiovascular system and related measurements, respiratory system and related measurements, laboratorial instrumentation and patient monitor system with consideration of patient safety issues related to biomedical instrumentation.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Directed self- study, • Team work (cooperative learning), • Mini/major project.	• Written tests (mid and final terms and quizzes), • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Presentations.
b2. Analyze, formulate and select suitable sensor comparing different standards and guidelines for the given industrial applications to make sensitive measurements of physical parameters, and predict correctly the expected performance of various sensors.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Directed self- study, • Team work (cooperative learning).	• Written tests (mid and final terms and quizzes), • Short reports, • 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 biostatistics, analytical techniques, and set up testing strategies to evaluate performance characteristics of different types of sensors and transducers, and develop professional skills in acquiring and applying the knowledge to design, analyze, and realize a circuit of signal conditioning from these sensors.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Directed self- study, • Team work (cooperative learning), • Mini/major project.	• Written tests (mid and final terms and quizzes), • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.
c2. Conduct appropriate experimentation related to sensors and transducers, and Locate different type of sensors used in real life applications and paraphrase their importance.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Exercises and home works, • Laboratory/Practical experiments based session, • Computer laboratory-based sessions, • Directed self- study,	• Written tests (mid and final terms and quizzes), • Lab\Project report • Practical lab performance assessment, • Coursework activities assessment, • Home works and assignments, • Presentations.

	• Team work (cooperative learning), • Mini/major project.	

(D) Alignment Course Intended Learning Outcomes of Transferable Skills to Teaching Strategies and Assessment Strategies:		
Course Intended Learning Outcomes	Teaching strategies	Assessment Strategies
d1. Demonstrate the ability to collaborative work as an effective member or leader of diverse teams, communicating effectively and operating within cross-disciplinary and cross-cultural contexts in the workplace, and the significance of time management in group work.	• Interactive lectures & examples, • Presentation/seminar, • Interactive class discussions, • Laboratory/Practical experiments based session, • Team work (cooperative learning), • Mini/major project.	• Written tests (mid and final terms and quizzes), • Practical lab performance assessment, • Coursework activities assessment, • Presentations.

IV. Course Content:

A – Theoretical Aspect:

Order	Units/Topics List	Sub Topics List	Number of Weeks	contact hours	Learning Outcomes
1	**Introduction**	– Introduction to the course. – Course outlines. – Project description.	1	2	a1, d1
2	**Sensors and Transducers: Basic Concepts of Measurements**	– Generalized medical instrumentation system. – Medical measurement constraints – Biostatistics. – General properties of input	2	4	a1, a3

		transducer. – Generalized static characteristics: accuracy, precision, resolution, reproducibility, sensitivity, drift, hysteresis, linearity, input impedance and output impedance. – Generalized dynamic characteristics: first order and second order characteristics, time delay, error free instrument, transfer functions. – Design criteria, generalized instrument specifications. – Classification, active, passive, mechanical, electrical, their comparison.			
3	**Temperature Sensors and Transducers:**	– Thermo-resistive transducers. – Thermoelectric, – p-n junction, – Chemical thermometry.	**1**	**2**	**a1, a3, b2, c2**
4	**Displacement Transducers:**	– Introduction. – Potentiometer, – Resistive strain gauges, – Capacitive displacement transducer, – Inductive displacement, – Force transducer.	**1**	**2**	**a1, a3, b2, c2**
5	**Pressure Transducer:**	– Variable capacitance pressure transducers,	1	2	**a1, a3, b2, c2**

		– LVDT transducers, – Strain gauge transducers, – Semiconductor transducers, – Catheter tip transducers.			
6	**Photoelectric Transducers:**	– Photo-emissive tubes, – Photovoltaic cell, – Photoconductive cell.	1	2	**a1, a3, b2, c2**
7	**Mid-Term Theoretical Exam**	- All previous topics.	1	2	**a1, a3, b2, c2**
8	**Flow Sensors and Transducers:**	– Different types of flow sensors and detectors. – Piezoelectric transducers and their applications. – Study of biological sensors: Sensors / receptors in the human body, basic organization of nervous system-neural mechanism and circuit processing.	1	2	**a1, a3, b2, c2**
9	**Biopotential Electrodes:**	– Microelectrodes, – Body surface electrodes, – Needle electrodes. – Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes. – Recording electrodes for ECG, EEG, and EMG. – Transducers for the measurement of ions and dissolved gases, pH electrode,	1	2	**a1, a3, b2, c2**

		specific ion electrodes.			
10	**Cardiovascular System and Measurements**	– The heart and cardiovascular system. – Instruments of ECG, blood pressure and its measurement. – Respiration and pulse rate. – Characteristics and measurement of blood flow meter, cardiac output. – Heart sounds and its measurement.	1	2	**a2, a3, b1, b2, c1, c2, d1**
11	**Respiratory System and Measurements**	– Measurement of pressure. – Measurement of gas flow. – Lung volume. – Respiratory plethysmography. – Measurement of gas concentration.	1	2	**a2, a3, b1, b2, c1, c2, d1**
12	**Patient Monitoring and Measurements**	– Measurement of heart rate. – Measurement of temperature. – Measurement of respiration rate.	1	2	**a2, a3, b1, b2, c1, c2, d1**
13	**Safety of Biomedical Instruments**	– Electrical safety. – Definition of electrical safety. – Macro shock and micro shock. – Design considerations for reducing electric hazards. – Specialized electric safety test equipment. – Mechanical safety. – Electromagnetic safety. – Biohazards and safety	1	2	**a1, b1**

		regulations.			
14	**Project Presentation**	Student's presentations.	**1**	**2**	**a1, a2, a3, b1, b2, c1, c2, d1**
15	**Final Theoretical Exam**	All topics.	1	2	**a1, a2, a3, b1, b2, c1, c2, d1**
Number of Weeks /and Units Per Semester			**16**	**32**	

B - Practical Aspect:

Order	Tasks/ Experiments	Number of Weeks	contact hours	Learning Outcomes
1	These will cover similar material to the lectures.	8	16	**a1, a3, b2, c1, c2, d1**
2	**Mid-Term Practical Exam**	1	2	**a1, a3, b2, c1, c2, d1**
3	These will cover similar material to the lectures.	5	10	**a1, a2, a3, b1, b2, c1, c2, d1**
4	**Final Practical Exam**	1	2	**a1, a2, a3, b1, b2, c1, c2, d1**
Number of Weeks /and Units Per Semester		**15**	**30**	

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Presentation/seminar,
- Interactive class discussions,
- Exercises and home works,
- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Directed self- study,

V. Teaching Strategies of the Course:

- Team work (cooperative learning),
- Mini/major project

VI. Assessment Methods of the Course:

- 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.

VII. Assignments:

No	Assignments	Aligned CILOs(symbols)	Week Due	Mark
1	Lectures 1,2,3, and 4 Assignment	**a1, a3, b2, c2, d1**	5	2
2	Lectures 5,6,7, and 9 Assignment	**a1, a3, b2, c2**	10	2
3	Lectures 10,11,12, and 13 Assignment	**a1, a2, a3, b1, b2, c1, c2, d1**	14	2
4	Project/ Presentation	**a1, a2, a3, b1, b2, c1, c2, d1**	15	4
Total				10

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	5,10,14,15	10	6.67%	**a1, a2, a3, b1,**

					b2, c1, c2, d1
2	Quiz 1	4	5	3.33%	**a1, a3, b2**
3	Midterm Theoretical Exam	8	20	13.33%	**a1, a3, b2, c2**
4	Quiz 2	12	5	3.33%	**a1, a2, a3, b1, b2**
5	Midterm Practical Exam	9	20	13.33%	**a1, a3, b2, c1, c2, d1**
6	Final Practical Exam	15	30	20%	**a1, a2, a3, b1, b2, c1, c2, d1**
7	Final Theoretical Exam	16	60	40%	**a1, a2, a3, b1, b2, c1, c2, d1**
Total			150	100%	

IX. Learning Resources:

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

1- Andrew G. Webb, 2018, "**Principles of Biomedical Instrumentation**", 1st Ed., UK, Cambridge University Press.

2- John G. Webster, Amit J. Nimunkar, 2020, "**Medical Instrumentation: Application and Design**", 5th Ed., USA, John Wiley & Sons Ltd.

2- Essential References.

1- Raghbir Singh Khandpur, 2020, "**Compendium of Biomedical Instrumentation**", 1st Ed., USA, John Wiley & Sons Ltd.

2- R.S. Khandpur, 2014, "**Handbook of Biomedical Instrumentation**", 3rd Ed., India, McGraw Hill Education (India) Private Limited.

3- Electronic Materials and Web Sites *etc*.

Websites:

1- The IEEE Engineering in Medicine and Biology (EMB) Society Wearable Biomedical Sensors and Systems Technical Committee (TC) is comprised of members interested in promoting the field of wearable and implantable body sensors within the biomedical

	community. https://www.embs.org/wbss/ 2- BIOPAC offers a wide range of high-quality, precision transducers for life science education and research data acquisition supporting human and animal experiments. https://www.biopac.com/product-category/education/transducers-education/ **Journals:** 1- Biosensors Journal is a peer reviewed journal that includes a wide range of topics in this field including Imaging sensors, DNA Biosensors, Microbial Biosensors, Ozone Biosensors, Bioreceptors, enzyme Interactions, Nucleic acid Interactions, Epigenetics, Surface attachment of the biological elements, Chemical sensors, Optical biosensors, Biomedical sensors, Electrochemical biosensors, Surface plasmon resonance, Graphene biosensors and Biotransducers. https://www.omicsonline.org/scholarly/biomedical-sensor-journals-articles-ppts-list.php 2- The Biomedical Sensors Section publishes original peer-reviewed papers covering all aspects of Biomedical Sensors. https://www.mdpi.com/journal/sensors/sections/biomedical_sensors **Other Web Sources:** 1- *Embedding Sensors and Motors* will introduce you to the design of sensors and motors, and to methods that integrate them into embedded systems used in consumer and industrial products. https://www.coursera.org/specializations/embedding-sensors-motors Biomedical Sensors: Types of sensors and How it works https://www.seeedstudio.com/blog/2019/10/14/biomedical-sensors-types-of-sensors-and-how-it-works/

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)

Biomedical Sensors and Measurements
BE224

I. Course Identification and General Information:					
1	**Course Title:**	Biomedical Sensors and Measurements			
2	**Course Code & Number:**	BE224			
3	**Credit Hours:**	**Credit Hours**	**Theory Hours**		**Lab. Hours**
			Lecture	**Exercise**	
		3	2	--	2
4	**Study Level/ Semester at which this Course is offered:**	3rd Level / 1st Semester			
5	**Pre –Requisite (if any):**	Engineering Physics (FR002), Physiology and Anatomy1,2 (BE161, BE162), General Biology (BE101), Electronics I (BE122),.			
6	**Co –Requisite (if any):**	Electronics II (BE223)			
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. Waleed Al-talabi			
11	**Reviewed by:**	Dr. Mohammed Al-Olofi			
12	**Date of Approval:**				

II. Course Description:

The Biomedical Sensors & Measurements course aims to give the student knowledge of detection methods of bio-signal, and types of sensors used in measurement. As well as, theories and techniques for electronic measurements on physiological systems. The course will cover circuits and sensors used to measure bio-signals including cardiovascular system and measurements, respiratory system and measurements, patient monitoring and measurements, and electrical hazards, safety, measuring instruments and techniques will be discussed. The corequisite laboratory will focus on the practical implementation of electronic devices for biomedical measurements.

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	Demonstrate understanding of the principles of measurement systems, measurement error and uncertainty, basic concepts of a variety sensors and transducers.
a2	Illustrate understanding of the physiology of biomedical system which is very important with respect to design consideration. As well as, discussing the application of electronics in diagnostics and therapeutic area.
a3	Describe how different measurement techniques are used to determine the vital parameters of diagnostic importance, and common methods for converting a physical parameter into an electrical quantity and provide an engineering approach to develop biomedical measurement systems.
B. Intellectual Skills: Upon successful completion of the course, students will be able to:	
b1	Design of basic measurement systems for biomedical applications, such as cardiovascular system and related measurements, respiratory system and related measurements, laboratorial instrumentation and patient monitor system with consideration of patient safety issues related to biomedical instrumentation.
b2	Analyze, formulate and select suitable sensor comparing different standards and guidelines for the given industrial applications to make sensitive measurements of physical parameters, and predict correctly the expected performance of various sensors.
C. Professional and Practical Skills: Upon successful completion of the course, students will be able	

III. Course Intended Learning Outcomes (CILOs): (مخرجات تعلم المقرر)	
to:	
c1	Use the biostatistics, analytical techniques, and set up testing strategies to evaluate performance characteristics of different types of sensors and transducers, and develop professional skills in acquiring and applying the knowledge to design, analyze, and realize a circuit of signal conditioning from these sensors.
c2	Conduct appropriate experimentation related to sensors and transducers, and Locate different type of sensors used in real life applications and paraphrase their importance.
D. Transferable Skills: Upon successful completion of the course, students will be able to:	
d1	Demonstrate the ability to collaborative work as an effective member or leader of diverse teams, communicating effectively and operating within cross-disciplinary and cross-cultural contexts in the workplace, and the significance of time management in group work.

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
1	**Introduction**	– Introduction to the course. – Course outlines. – Project description.	1	2
2	**Sensors and Transducers: Basic Concepts of Measurements**	– Generalized medical instrumentation system. – Medical measurement constraints – Biostatistics. – General properties of input transducer. – Generalized static characteristics: accuracy, precision, resolution, reproducibility, sensitivity, drift, hysteresis, linearity, input	2	4

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		impedance and output impedance. – Generalized dynamic characteristics: first order and second order characteristics, time delay, error free instrument, transfer functions. – Design criteria, generalized instrument specifications. – Classification, Active, Passive, Mechanical, Electrical, their comparison.		
3	**Temperature Sensors and Transducers:**	– Thermo-resistive transducers. – Thermoelectric, – p-n junction, – Chemical thermometry.	**1**	**2**
4	**Displacement Transducers:**	– Introduction. – Potentiometer, – Resistive strain gauges, – Capacitive displacement transducer, – Inductive displacement, – Force transducer.	**1**	**2**
5	**Pressure Transducer:**	– Variable capacitance pressure transducers, – LVDT transducers, – Strain gauge transducers,	1	2

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– Semiconductor transducers, – Catheter tip transducers.		
6	**Photoelectric Transducers:**	– Photo-emissive tubes, – Photovoltaic cell, Photoconductive cell.	1	2
7	**Mid-Term Theoretical Exam**	– - All previous topics.	1	2
8	**Flow Sensors and Transducers:**	– Different types of flow sensors and detectors. – Piezoelectric transducers and their applications. – Study of biological sensors: Sensors / receptors in the human body, basic organization of nervous system-neural mechanism and circuit processing.	1	2
9	**Biopotential Electrodes:**	– Microelectrodes, – Body surface electrodes, – Needle electrodes. – Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes. – Recording electrodes for ECG, EEG, and EMG. – Transducers for the measurement of ions and dissolved gases, pH	1	2

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		electrode, specific ion electrodes.		
10	**Cardiovascular System and Measurements**	– The heart and cardiovascular system. – Instruments of ECG, blood pressure and its measurement. – Respiration and pulse rate. – Characteristics and measurement of blood flow meter, cardiac output. – Heart sounds and its measurement.	1	2
11	**Respiratory System and Measurements**	– Measurement of pressure. – Measurement of gas flow. – Lung volume. – Respiratory plethysmography. – Measurement of gas concentration.	1	2
12	**Patient Monitoring and Measurements**	– Measurement of heart rate. – Measurement of temperature. Measurement of respiration rate.	1	2
13	**Safety of Biomedical Instruments**	– Electrical safety. – Definition of electrical safety. – Macro shock and micro shock. – Design considerations for reducing electric hazards. – Specialized electric safety test equipment. – Mechanical safety.	1	2

IV. Course Contents:

A. Theoretical Aspect:

No.	Units/Topics List	Sub Topics List	Number of Weeks	Contact Hours
		– Electromagnetic safety. – Biohazards and safety regulations.		
14	**Project Presentation**	Student's presentations.	**1**	**2**
15	**Final Theoretical Exam**	All topics.	1	2
Number of Weeks /and Units Per Semester			**16**	**32**

B. Case Studies and Practical Aspect:

No.	Tasks/ Experiments	Number of Weeks	Contact Hours
1	These will cover similar material to the lectures.	8	16
2	**Mid-Term Practical Exam**	1	2
3	- These will cover similar material to the lectures.	5	10
4	- **Final Practical Exam**	1	2
Number of Weeks /and Units Per Semester		**15**	**30**

V. Teaching Strategies of the Course:

- Interactive lectures & examples,
- Presentation/seminar,
- Interactive class discussions,
- Exercises and home works,

V. Teaching Strategies of the Course:

- Laboratory/Practical experiments based session,
- Computer laboratory-based sessions,
- Directed self- study,
- Team work (cooperative learning),
- Mini/major project.

VI. Assessment Methods of the Course:

- 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.

VII. Assignments:

No.	Assignments	Week Due	Mark
1	**Lectures 1,2,3, and 4 Assignment**	5	2
2	**Lectures 5,6,7, and 9 Assignment**	10	2
3	**Lectures 10,11,12, and 13 Assignment**	14	2
4	**Project/ Presentation**	15	4
Total			**10**

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

No.	Assessment Method	Week Due	Mark	Proportion of Final Assessment
1	**Project/ Assignments**	5,10,14, 15	10	6.67%
2	**Quiz 1**	4	5	3.33%
3	**Midterm Theoretical Exam**	8	20	13.33%
4	**Quiz 2**	12	5	3.33%
5	**Midterm Practical Exam**	9	20	13.33%
6	**Final Practical Exam**	15	30	20%
7	**Final Theoretical Exam**	16	60	40%
Total			**150**	**100%**

IX. Learning Resources:

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

1- Andrew G. Webb, 2018, "**Principles of Biomedical Instrumentation**", 1st Ed., UK, Cambridge University Press.

2- John G. Webster, Amit J. Nimunkar, 2020, "**Medical Instrumentation: Application and Design**", 5th Ed., USA, John Wiley & Sons Ltd.

2- Essential References.

1- Raghbir Singh Khandpur, 2020, "**Compendium of Biomedical Instrumentation**", 1st Ed., USA, John Wiley & Sons Ltd.

2- R.S. Khandpur, 2014, "**Handbook of Biomedical Instrumentation**", 3rd Ed., India, McGraw Hill Education (India) Private Limited.

3- Electronic Materials and Web Sites *etc*.

Websites:

1- The IEEE Engineering in Medicine and Biology (EMB) Society Wearable Biomedical Sensors and Systems Technical Committee (TC) is comprised of members interested in promoting the field of wearable and implantable body sensors within the biomedical

	community. https://www.embs.org/wbss/ 2- BIOPAC offers a wide range of high-quality, precision transducers for life science education and research data acquisition supporting human and animal experiments. https://www.biopac.com/product-category/education/transducers-education/ **Journals:** 1- Biosensors Journal is a peer reviewed journal that includes a wide range of topics in this field including Imaging sensors, DNA Biosensors, Microbial Biosensors, Ozone Biosensors, Bioreceptors, enzyme Interactions, Nucleic acid Interactions, Epigenetics, Surface attachment of the biological elements, Chemical sensors, Optical biosensors, Biomedical sensors, Electrochemical biosensors, Surface plasmon resonance, Graphene biosensors and Biotransducers. https://www.omicsonline.org/scholarly/biomedical-sensor-journals-articles-ppts-list.php 2- The Biomedical Sensors Section publishes original peer-reviewed papers covering all aspects of Biomedical Sensors. https://www.mdpi.com/journal/sensors/sections/biomedical_sensors **Other Web Sources:** 1- *Embedding Sensors and Motors* will introduce you to the design of sensors and motors, and to methods that integrate them into embedded systems used in consumer and industrial products. https://www.coursera.org/specializations/embedding-sensors-motors Biomedical Sensors: Types of sensors and How it works https://www.seeedstudio.com/blog/2019/10/14/biomedical-sensors-types-of-sensors-and-how-it-works/

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.