Jordan University of Science and Technology
Faculty of Engineering
Biomedical Engineering Department

BME 413 Biomedical Sensors

Second Semester 2016/2017

Course Catalog

3 Credit hours (3 h lectures). Introduction to biomedical sensors: definition, classification, calibration, requirements, errors and uncertainty, static and dynamic parameters, requirements and design aspects of signal conditioning circuits, temperature sensors: types, and signal processing circuits, Pressure sensors: types, operating principle, calibration techniques, medical applications and conditioning procedures, Electrochemical sensors, Ion-selective sensors, Biosensors, Ion-sensitive field effect chemo-sensors, optical sensors, Ultrasound transducers, Intelligent biomedical sensors, manufacturing of biomedical sensors.

Text Book(s)

Title	Sensors and Signal Conditioning (Textbook 1)
Author(s)	Ramon Pallas-Areny and John G. Webster
Publisher	John Wiley & Sons
Year	2001
Edition	2nd Edition
Title	Biosensors: An Introduction (Textbook 2)
Author(s)	Eggins, Brian
Publisher	John Wiley & Sons
Year	1996
Edition	1st Edition

References

Books

1. Yang, V. C., and Ngo, T. T., (2000), Biosensors and their Applications, Kluwer Academic/Plenum Publisher, New York.
2. Harsanyi, G , (2000), Sensors in Biomedical Applications: Fundamentals, Technology and Applications, Technomic Publishing Company.
3. Hall, E. A., (1990), Biosensors, open University Press, Milton Keynes,
4. Geddes, L. A., and Baker, L. E. (1989), Principles of Applied Biomedical Bnstrumentation, 3rd ed., New York: Wiley.
5. Janata, J. (1989), Principles of Chemical Sensors, New York: Plenum.
6. Bronzino, J., (2000), The Biomedical Engineering Handbook, 2nd Edition, CRC Press.

Journals

1. IEEE Transactions on Biomedical Engineering
2. Journal of Medical Engineering and Technology

	3. Sensors and Actuators 4. Physiological Measurements 5. Biomedical Engineering Online 6. Annals of Biomedical Engineering Journal Papers 1. Mendelson, Y. M., Clermont, A. C., Peura, R. A., and Lin, B. C., Blood glucose measurement by multiple attenuated total reflection and infrared absorption spectroscopy, *IEEE Transactions on Biomedical Engineering*,1990, 37, 458-465. 2. Rolfe, R., Review of chemical sensors for physiological measurement, *Journal of Biomedical Engineering*, 1988, 10, 138-145. 3. Mendelson, Y. M., Peura, R. A., Noninvasive transcutaneous monitoring of arterial blood gases, *IEEE Transactions on Biomedical Engineering*, 1984, 31, 792-800. 4. Hansen, a. T., Fiber-optic pressure transducers for medical applications, *Sensors and actuators*, 1983, 4, 545-554. 5. Meyerhoff, ME and Opdycke, WN, Ion Selective Electrodes, *Advances in Clinical Chemistry*, 1986, 25, 1-47.
Internet links	http://www.orionres.com http:// www.gl.iit.edu/subject/**biomedical**/ref.htm http:// www.vonl.com/chips/biomedtr.htm http:// www.ibmt.fraunhofer.de/Produktblaetter/SM_ms_fpwtransducer_en.p http:// www. depts.washington.edu/bioe/programs/bachelors/syllabus/BIOEN573.pdf

Instructor	
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Teaching Assistant
To be Assigned by BME Department

Objectives and Outcomes

Objectives	Outcomes
1. Analyze errors and uncertainty of experimental results obtained from biomedical sensors. [a, b, j, k].	1.1. Define biomedical sensors, biosensors, and biomedical transducers. 1.2. Classify the biomedical sensors. 1.3. Explain the calibration procedure and standards. 1.4. Explain procedures for determination errors and uncertainty.
2. Understand requirements, calibration, characteristics and parameters of biomedical sensors [a, b, e, h, j]	2.1. Recognize the requirements of biomedical sensors 2.2. Explain the Static and dynamic characteristics of biomedical sensors 2.3. Study the effect of environmental parameters 2.4. Identify the methods for characterization of biomedical sensors

3. Design with confidence signal conditioning systems required for processing the sensors responses [b, c, e]]	3.1 Explain the requirements of signal conditioning circuits suitable for biomedical sensors 3.2. Identify design principles of conditioning circuits 3.3. Apply design techniques for designing signal conditioners for different types of biomedical sensors
4. Understand the operating principle, types, parameters, signal conditioning, and applications of resistive, reactance variation and self-generating sensors [a, b, c, e, h, j, k].	4.1. Identify the different types of resistive, reactance variation and self-generating sensors. 4.2. Explain the operating principle, parameters, calibration and applications of resistive, reactance variation and self-generating sensors. 4.3. Design appropriate signal conditioning circuits to different types of resistive, reactance variation and self-generating sensors.
5. Study the design, operating principle, types, parameters, signal conditioning, and applications of electrochemical sensors and Biosensors [a, b, c, e, h, j, k]	5.1. Differentiate between the different types of electrochemical sensors and biosensors. 5.2. Explain the operating principle, parameters and calibration of electrochemical gas sensors, ion-selective electrodes, biosensors and ISFET chemosensors. 5.3. Identify the needs for biological elements (enzymes, antibodies, nucleic acids and receptors) in biosensors. 5.4. Evaluate the immobilization of biological component (adsorption, microencapsulation, entrapment, cross-linking, and covalent bonding). 5.5. Design various types of chemical sensors. 5.6. Design of signal conditioning circuit for different types of electrochemical chemical sensors and biosensors. 5.7. Discuss the advantages and drawbacks of available electrochemical sensors. 5.8. Explain clinical applications of electrochemical sensors and biosensors.
6. Understand the operating principle of different types of optical sensors and their features [a, b, c, e, j]	6.1. Identify the different types of optical sensors 6.2. Reveal the advantages of optical sensors 6.3. Discuss the operating principle, calibration, parameters and applications of optical sensors. 6.4. Explain the design techniques of optical sensors 6.5.Explain the design procedure of signal conditioners suitable for optical sensors
7. Understand the operation, models and parameters of ultrasound transducers [a, b, c, e, j, k]	7.1. Classify ultrasound transducers 7.2. Recognize the main parts 7.3. Explain the operating principle, parameters and models of ultrasound transducers. 7.4. Design of single-element single layer ultrasound transducer
7. Understand the design, main building blocks, features and calibration of intelligent sensors [a, b, e, h, j, k, i]	8.1. Define intelligent sensor 8.2. List the main features of intelligent sensors 8.3. Explain the main building blocks of intelligent sensors 8.4. Discuss the operating principle, parameters and applications of intelligent sensors 8.5. Explain the calibration procedure of biomedical intelligent sensors
9. Encourage life long learning, foster teamwork and enhance students' communication and soft skills [d, e, f, g, h, i].	9.1. Write technical report and give oral presentation on team work projects. 9.2. Use software packages for design and simulation of signal conditioning circuits implemented using these sensors

[1] **L**ower case letters refer to the program outcomes

Topics Covered		
Week	**Topics**	**Chapters in Textbook**
1-2	**Introduction to Biomedical Sensors** General concept and terminology, Sensor classification and calibration, static and dynamic characteristics, errors and uncertainty.	Chapter 1 (Textbook 1)
2-3	**Resistive Sensors and their signal conditioning** Potentiometers, Strain gages, Resistive Temperature Detectors (RTD), Thermistors, light-dependent resistors, signal conditioning for resistive sensors	Chapter 2 and Chapter 3 (Textbook 1)
4-6	**Reactance Variation and Electromagnetic Sensors** Capacitive sensors, Inductive sensors, Electromagnetic sensors, signal conditioning for reactance variation sensors,	Chapter 4 and Chapter 5 (Textbook 1)
7-9	**Self-Generating Sensors and Signal Conditioning** Thermoelectric sensors, Piezoelectric sensors, Electrochemical sensors, Signal conditioning for self-generating sensors.	Chapter 6 and Chapter 7 (Textbook 1)
10-11	**Optical Sensors** Optical techniques, General principles of optical sensing, Fiber-optic basics, Fiber-optic sensor technologies and applications.	Chapter 9 (Textbook 1)
12-13	**Ultrasound Transducers** Fundamentals of ultrasonic-based sensors, Ultrasonic-based sensing methods and applications.	Chapter 9 (Textbook 1)
14	**Intelligent Sensors** Definition, parameters, features, operating principle , main building blocks and applications.	Chapter 8 ((Textbook 1)
15-16	**Biosensors** Operating principle, biological elements in biosensors, Immobilization of the biological component , applications and signal conditioning	Chapter 9 (Textbook 1) Chapter s 1-3 (Textbook 2)

Evaluation		
Assessment Tool	**Expected Due Date**	**Weight**
Homework, Quizzes & Term Project	One week after homework problems are assigned	10%
First Exam	According to the Department schedule	25 %
Second Exam	According to the Department schedule	25 %
Final Exam	According to the University final examination schedule	40 %

Teaching & Learning Methods

- Active learning, where students should be active and involved in the learning process inside the classroom, will be emphasized in the delivery of this course.
- Different active learning methods/approaches such as: Engaged Learning, Project-Based Learning, Cooperative Learning, Problem-based Learning, Structured Problem-solving, will be used.
- The teaching method that will be used in this course will be composed of a series of mini lectures interrupted with frequent discussions and brainstorming exercises. PowerPoint presentations will be prepared for the course materials.
- A typical lecture would start with a short review (~ 5 minutes) using both PowerPoint presentations and the blackboard. This review will also depend on discussions which will gauge the students' digestion of the previous material. Then, the students would have a lecture on new materials using PowerPoint presentations and blackboard. The lecture presentation will be paused every 15 – 20 minutes with brainstorming questions and discussions that will allow the students to reflect and think in more depth about what they learned in that presentation. Then, some example problems will be presented and discussed with the students to illustrate the appropriate problem solving skills that the students should learn. The lecture will be continued for another 15 – 20 minutes, followed by examples and/or a quiz covering the materials taught in the previous two weeks.

Policy

Attendance	Class attendance is required and applied according to the university regulations (S**tudent's Guide**). Data support the idea that class attendance improves learning. It is very difficult as well as uninspiring for me to help a student who does not attend lectures. What is created in the classroom cannot be reenacted. Make-up tests will be done according to the university regulations. Please see student's guide
Homework	Working homework problems is an essential part of this course and they represent a key opportunity to learn the subjects discussed. All homework problems assigned during a given week are due at the beginning of class on the second meeting of the following week unless otherwise stated. Late homework will not be accepted. Failure to turn in this particular homework **on time** will result in a grade of 0 (zero) for the homework contribution to your final grade. Team work is encouraged; however, the work one hands in must represent his/her own effort. Homework solutions will be discussed in class. There will be no handouts of homework solutions.
Project	**Abstract** Every group (2-3) must do a term project. Each group must submit a project Abstract on November 15th, 2009. This Abstract should be at most one page and must include: Project title Introduction References **REPORT:** The report is due at the project presentations during the final week of classes. The submitted report should include a list of which student was responsible for each section of the report. **PRESENTATION AND DEMONSTRATION:** There will be a formal presentation and demonstration for each project. All presentations will be made during the final week of classes. The presentation should be limited to 10 minutes.
Student Conduct	All University regulations apply to this course. In particular, the policies concerning academic dishonesty and withdrawal from a course apply. **Dec 24th** is the last day to withdraw. I will sign drop slips without restriction.

Contribution of Course to Meeting the Professional Component
The course contributes to building the fundamental basic concepts in Biomedical Engineering.

ABET Category Content	
Engineering Science	3.0 Credits
Engineering Design	

Prepared by: **Prof. Mashhour Bani Amer**

BME 413: Bioengineering Signals and Systems Fall Semester 1. Basic Information: Course: Bioengineering Signals and Systems, BME 413, 4 units Place and time: MW 12-1:50PM KDC 240 Discussion Sections: F 12-12:50PM VHE 210 and F 1-1:50PM VHE 206 Faculty: Brent J. Liu, Ph.D., Associate Professor, BME Department Office: Denny Research Center (DRB).Â to solve problems in the Biomedical Engineering field. Learning Objectives and Specific Course Outcomes Outcome 1: Understand and explore basic signals and their signal properties in Bioengineering. Outcome 2: Have general knowledge of how to apply principles of time and frequency domain analysis to solve problems in Biomedical Engineering.