The University of Texas at Tyler
Department of Electrical Engineering

EENG 4341 – Biosensor Design

Syllabus

Catalog Description:

The purpose of this course is to provide a detailed understanding of biosensors and underlying engineering principles used to detect biomolecules such as DNA, proteins, and cells having applications in diagnostics and environmental monitoring. Students will also work in teams to conduct a comprehensive literature survey of some interesting biosensing platforms.

Prerequisites:	EENG 3306, EENG 3106, EENG 3305

Credits:	(	3	hours lecture,	0	hours laboratory per week)

Text(s):	Lecture notes, additional materials, and examples will be made available through Canvas. (**required**) Narayanaswamy, Ramaier, and Otto S. Wolfbeis. *Optical sensors: industrial, environmental and diagnostic applications.* Vol. 1. Springer Science & Business Media, 2004. (**recommended**) Yoon, Jeong-Yeol. *Introduction to biosensors: from electric circuits to immunosensors*. Springer Science & Business Media, 2012. (**recommended**)

Additional Material:	Engineering paper, scientific calculator; MATLAB, and Excel
Course Coordinator:	Shawana Tabassum

Topics Covered: (paragraph of topics separated by semicolons)

Topics emphasize the design, selection, and operation of various biosensing techniques including electrochemistry, optics, fluorescence, and acoustics. In addition, the steps of functionalizing the transducer surfaces, characterization of biosensor performance, data interpretation, blood glucose detection, and label-free biochips, will be discussed.

Evaluation Methods: (only items in dark print apply):

1. Examinations / Quizzes
2. Homework
3. Report

4. Computer Programming
5. Project
6. Presentation
7. Course Participation
8. Peer Review

Course Objectives[2]: By the end of this course students will be able to:

1. Understand the working principle of the major classes of biosensors: electrochemical, optical, fluorescence, and acoustics-based sensors. [1,2,5,7]
2. Learn the fundamentals of bio selective layers including depositing films and membranes, immobilizing surfaces with bio selective agents. [1,2,5,7]
3. Compare and contrast different types of biomolecular assays: label-free vs labeled and homogeneous vs heterogeneous assays. [1,2,5,7]
4. Analyze the data generated by biosensors using coefficient of variance, receiver operating characteristic (ROC) curve, etc. [5,6]
5. Examine the major applications of biosensor technology in diagnostic tests, life science research, and environmental testing. [1,2,5]
6. Analyze the performance metrics, aka figures of merit (e.g., sensitivity, specificity, dynamic range, limit-of-detection, etc.) of a biosensor. [5,6]
7. Develop literature research skills, creative thinking, presentation and report-writing skills through a survey of the most recent biosensing platforms (e.g. Covid-19). [5,6]

[2]*Numbers in brackets refer to method(s) used to evaluate the course objective.*

Relationship to Program Outcomes (only items in dark print apply)[3]: This course supports the following Electrical Engineering Program Outcomes, which state that our students will:

1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics [1-3,5];
2. an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors [4,6,7];
3. an ability to communicate effectively with a range of audiences
4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts
5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives [7]

6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions [4,6,7];
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies. [4,6,7]

[3] Numbers in brackets refer to course objective(s) that address the Program Outcome.

Prepared By:	Shawana Tabassum	Date:	19 August 2022

EENG 4341: Biosensor Design

"Learning is a 2-way street. We also look forward to learning from you!"

Course-Instructors

Shawana Tabassum, PhD

Email: stabassum@uttyler.edu (preferred)

Response time: I try to respond to all emails within one business day. I do not regularly check emails on weekends, holidays, and school breaks, so response time may be longer at these times.

Office Hours: Tue, Wed, Thu from 4-5PM

Assignment/Project query sessions on biosensing:

feel free to email me if the above times do not work for you

Course Website

Lecture notes and assignments will be posted on Canvas

Textbook & Resources

Lecture notes, additional materials, and examples will be made available through Canvas. (**required**)

Narayanaswamy, Ramaier, and Otto S. Wolfbeis. *Optical sensors: industrial, environmental and diagnostic applications.* Vol. 1. Springer Science & Business Media, 2004. (**recommended**)

Yoon, Jeong-Yeol. *Introduction to biosensors: from electric circuits to immunosensors*. Springer Science & Business Media, 2012. (**recommended**)

NOTE: Students are not under any obligation to purchase a textbook from a university-affiliated bookstore. Textbooks can be purchased from any independent retailer including an online retailer.

Course Description

The purpose of this course is to provide a detailed understanding of biosensors and underlying engineering principles used to detect DNA, proteins, and cells having applications in diagnostics and environmental monitoring. Topics emphasize the design, selection, and operation of various biosensing techniques including electrochemistry, optics, fluorescence, and acoustics. Moreover, the steps of functionalizing the transducer surfaces, characterization of biosensor performance, data interpretation, blood glucose detection, and label-free biochips, will be discussed.

Course Goal

By the end of this course students will be able to design and analyze a biosensing device targeted to specific applications including diagnostic tests, life science research, or environmental monitoring.

Learning Objectives

Upon completion of this course, the students will be able to:

- Understand the principle of operation of the major classes of biosensors: electrochemical, optical, fluorescence, and acoustics-based sensors.
- Learn the fundamentals of bio selective layers including depositing films and membranes, immobilizing surfaces with bio selective agents.
- Compare and contrast different types of biomolecular assays: label-free vs labeled and homogeneous vs heterogeneous assays.
- Analyze the data generated by biosensors using coefficient of variance, receiver operating characteristic (ROC) curve, etc.
- Examine the major applications of biosensor technology in diagnostic tests, life science research, and environmental testing
- Analyze the performance metrics, aka figures of merit (e.g., sensitivity, specificity, dynamic range, limit-of-detection, etc.) of a biosensor
- Develop literature research skills, creative thinking, presentation and report-writing skills through a survey of the most recent biosensing platforms (e.g. Covid-19)

Course Outline

Schedule	Topics	Assignments
Week 1: August 25	Introduction to the course What is a biosensor? Analysis of biosensor output	Review Syllabus
Week 2: September 1	Immobilization methods of bio selective layers	
Week 3: September 8	Mechanisms of mass transport	Assignment 1 due on 9/11/2022
Week 4: September 15	Biomolecular assays: label-free vs labeled and homogeneous vs heterogeneous	
Week 5: September 22	Figures of merit	Assignment 2 due on 9/25/2022
Week 6: September 29	Electrochemical sensors I	
Week 7: October 6	Midterm exam review Electrochemical sensors II	Assignment 3 due on 10/9/2022
Week 8: October 13	Midterm Exam	
Week 9: October 20	Acoustic sensors	Assignment 4 due on 10/23/2022
Week 10: October 27	Optical sensors I	
Week 11: November 3	Optical sensors II	Assignment 5 due on 11/6/2022
Week 12: November 10	Micro and nanoparticles	
Week 13: November 17	Microarray and microfluidics-based lab-on-a-chip technology	Assignment 6 due on 11/20/2022
Week 14: November 24	Thanksgiving break	
Week 15: December 1	Final exam review Short presentations	Survey report due on 12/4/2022
Week 16:	Final exam	

Grading Scheme

The overall distribution of grades is obtained as:

Assignments	30%
Survey report	35%
Midterm	15%
Final Exam	15%
Course participation	5%
Total	100%

* indicates number

Grading Scale

Letter Grades	Range
A	90-100
B	80-89
C	70-79
D	60-69
F	59 and below

Course Policies

Attendance Policy:

Attendance is 5% of the total grade.

Assignment Policy:

- There will be several assignments throughout the course period. Please check their due dates under the course outline above.
- Late assignments will NOT be graded. Make-up or late submission will be allowed only with a prior arrangement with the instructor, or for emergency (e.g., medical); adequate documentation should be provided for the same. (See the late assignments and make-up policy below)
- You will have to submit the assignments and survey report through Canvas using pdf or word format. But, please remember if you take picture and upload, your writing has to be LEGIBLE. Otherwise, we might ask you to resubmit.

You are always welcome to discuss with your peers regarding any assignments/projects, as cooperative learning can result in higher achievement than individual learning. Feel free to work with your peers. However, do NOT copy, paste and use materials from your peers. That will be counted as PLAGIARISM.

All resources, including materials obtained from internet, should be properly cited.

Exam Policy:

- There will be one midterm and one final exam (check the course outline above)
- All exams will be closed book/note and no collaboration is allowed
- Review sessions for the midterm and final will be held during the class time

Late assignments and make-up policy:

Accommodation of the following absences will be ensured.

1. Extra-curricular activities as a representative of UT Tyler (e.g., sponsored sports, band, conference presentations, etc.).
2. Military service (including National Guard, ROTC).
3. Officially mandated court appearances (including jury duty).

In all cases, the person or agency responsible for the event or activity should provide participants with a letter explaining the proposed absence and its duration, including travel times for off-campus events and activities. Students must provide this documentation to instructors **at least two weeks prior** to the activity or event, except when such notice is not possible.

Other Absences Granting requests for accommodating other absences is at the discretion of the instructor. That is, the instructor will review the situation in an effort to provide a reasonable accommodation and arrange for possible make-up when possible to do so, without fundamentally altering a course or creating an undue burden for the instructor or department. Official documentation is required whenever possible and must be provided at the earliest opportunity. This policy is intended primarily for the following situations:

4. Medical excuse.
5. Family emergency.
6. Religious observances and practices. Students who request religious accommodation should do so in writing during the first week of the semester. Students may seek assistance from Dean of Students Office.

Expected online or classroom behaviors:

Students are highly encouraged to be considerate.

- ***Be respectful:*** Please be respectful even in an online environment. Do not say anything you would not say in a face-to-face classroom. This includes attacking someone, dominating a discussion, controlling the class agenda, etc.
- ***Be a responsible citizen:*** Please do not engage in activities that is disruptive to the rest of the class. The instructor should also take into consideration complaints of disruptive behavior brought to their attention by students. Should any student officially enrolled for credit or audit in a class disrupt the instructor's ability to ensure a safe environment and/or deliver the approved curriculum, the instructor has the right to ask that the disruptive action cease immediately. The responsible student should cease the disruption and utilize non-disruptive means for expressing disagreement or concern. If the disruption continues, the instructor can pursue various forms of intervention, including suspension from class and use of student disciplinary regulations.

Busting the Myth of "Online students don't have access to resources":

- UT Tyler Writing Center (903.565.5995), writingcenter@uttyler.edu , https://www.uttyler.edu/writingcenter/onlinetutoringinfo.php
- UT Tyler Tutoring Center (903.565.5964), tutoring@uttyler.edu
- The Mathematics Learning Center, RBN 4021, this is the open access computer lab for math students, with tutors on duty to assist students who are enrolled in early-career courses.
- UT Tyler Academic Advising, https://www.uttyler.edu/advising/
- UT Tyler Counseling Center (903.566.7254), https://www.uttyler.edu/counseling/
- UT Tyler Canvas support, https://www.uttyler.edu/canvas/. See below for more information
- UT Tyler Technology support, https://www.uttyler.edu/ccs/
- UT Tyler Student Accessibility and Resources, https://www.uttyler.edu/disabilityservices/
- UT Tyler Library support, https://www.uttyler.edu/library/
- UT Tyler PASS Tutoring Center, https://www.uttyler.edu/tutoring/
- UT Tyler Veterans Resources, https://www.uttyler.edu/military-and-veterans-success-center/?r=/veteransaffairs/
- UT Tyler Student Health and Wellness, https://www.uttyler.edu/wellness/onlineresources.php

Academic Misconduct

Disciplinary proceedings may be initiated against any student who engages in scholastic dishonesty, including, but not limited to, cheating, plagiarism, collusion, the submission for credit of any work or materials that are attributable in whole or in part to another person, taking an examination for another person, any act designed to give unfair advantage to a student or the attempt to commit such acts.

i. "Cheating" includes, but is not limited to:

- copying from another student's test paper;
- using, during a test, materials not authorized by the person giving the test;
- failure to comply with instructions given by the person administering the test;
- possession during a test of materials which are not authorized by the person giving the test, such as class notes or specifically designed "crib notes". The presence of textbooks constitutes a violation if they have been specifically prohibited by the person administering the test;
- using, buying, stealing, transporting, or soliciting in whole or part the contents of an unadministered test, test key, homework solution, or computer program;
- collaborating with or seeking aid from another student during a test or other assignment without authority;
- discussing the contents of an examination with another student who will take the examination;
- divulging the contents of an examination, for the purpose of preserving questions for use by another, when the instructors has designated that the examination is not to be removed from the examination room or not to be returned or to be kept by the student;
- substituting for another person, or permitting another person to substitute for oneself to take a course, a test, or any course-related assignment;
- paying or offering money or other valuable thing to, or coercing another person to obtain an unadministered test, test key, homework solution, or computer program or information about an unadministered test, test key, home solution or computer program;
- falsifying research data, laboratory reports, and/or other academic work offered for credit;
- taking, keeping, misplacing, or damaging the property of The University of Texas at Tyler, or of another, if the student knows or reasonably should know that an unfair academic advantage would be gained by such conduct; and
- misrepresenting facts, including providing false grades or resumes, for the purpose of obtaining an academic or financial benefit or injuring another student academically or financially.

ii. "Plagiarism" includes, but is not limited to, the appropriation, buying, receiving as a gift, or obtaining by any means another's work and the submission of it as one's own academic work offered for credit.

iii. "Collusion" includes, but is not limited to, the unauthorized collaboration with another person in preparing academic assignments offered for credit or collaboration with another person to commit a violation of any section of the rules on scholastic dishonesty.

iv. All written work that is submitted will be subject to review by plagiarism software.

University Policies

People learn differently, and our goal is to ensure everyone is learning, regardless of their needs. We will make every effort to accommodate the needs of students with different learning abilities.

UT Tyler Honor Code:

Every member of the UT Tyler community joins together to embrace: Honor and integrity that will not allow me to lie, cheat, or steal, nor to accept the actions of those who do.

Students Rights and Responsibilities:

To know and understand the policies that affect your rights and responsibilities as a student at UT Tyler, please follow this link: http://www.uttyler.edu/wellness/rightsresponsibilities.php

Campus Carry:

We respect the right and privacy of students 21 and over who are duly licensed to carry concealed weapons in this class. License holders are expected to behave responsibly and keep a handgun secure and concealed. More information is available at http://www.uttyler.edu/about/campus-carry/index.php

UT Tyler a Tobacco-Free University:

All forms of tobacco will not be permitted on the UT Tyler main campus, branch campuses, and any property owned by UT Tyler. This applies to all members of the University community, including students, faculty, staff, University affiliates, contractors, and visitors.

Forms of tobacco not permitted include cigarettes, cigars, pipes, water pipes (hookah), bidis, kreteks, electronic cigarettes, smokeless tobacco, snuff, chewing tobacco, and all other tobacco products.

There are several cessation programs available to students looking to quit smoking, including counseling, quitlines, and group support. For more information on cessation programs please visit www.uttyler.edu/tobacco-free.

Grade Replacement/Forgiveness and Census Date Policies:

Students repeating a course for grade forgiveness (grade replacement) must file a Grade Replacement Contract with the Enrollment Services Center (ADM 230) on or before the Census Date of the semester in which the course will be repeated. Grade Replacement Contracts are available in the Enrollment Services Center or at http://www.uttyler.edu/registrar. Each semester's Census Date can be found on the Contract itself, on the Academic Calendar, or in the information pamphlets published each semester by the Office of the Registrar.

Failure to file a Grade Replacement Contract will result in both the original and repeated grade being used to calculate your overall grade point average. Undergraduates are eligible to exercise grade replacement for only three course repeats during their career at UT Tyler; graduates are eligible for two grade replacements. Full policy details are printed on each Grade Replacement Contract.

The Census Date is the deadline for many forms and enrollment actions of which students need to be aware. These include:

- Submitting Grade Replacement Contracts, Transient Forms, requests to withhold directory information, approvals for taking courses as Audit, Pass/Fail or Credit/No Credit.
- Receiving 100% refunds for partial withdrawals. (There is no refund for these after the Census Date)
- Schedule adjustments (section changes, adding a new class, dropping without a "W" grade)
- Being reinstated or re-enrolled in classes after being dropped for non-payment
- Completing the process for tuition exemptions or waivers through Financial Aid

State-Mandated Course Drop Policy:

Texas law prohibits a student who began college for the first time in Fall 2007 or thereafter from dropping more than six courses during their entire undergraduate career. This includes courses dropped at another 2-year or 4-year Texas public college or university. For purposes of this rule, a dropped course is any course that is dropped after the census date (See Academic Calendar for the specific date).

Exceptions to the 6-drop rule may be found in the catalog. Petitions for exemptions must be submitted to the Enrollment Services Center and must be accompanied by documentation of the extenuating circumstance. Please contact the Enrollment Services Center if you have any questions.

Disability/Accessibility Services:

In accordance with Section 504 of the Rehabilitation Act, Americans with Disabilities Act (ADA) and the ADA Amendments Act (ADAAA) the University of Texas at Tyler offers accommodations to students with learning, physical and/or psychological disabilities. If you have a disability, including a non-visible diagnosis such as a learning disorder, chronic illness, TBI, PTSD, ADHD, or you have a history of modifications or accommodations in a previous educational environment, you are encouraged to visit https://hood.accessiblelearning.com/UTTyler and fill out the New Student application. The Student Accessibility and Resources (SAR) office will contact you when your application has been submitted and an appointment with Cynthia Lowery, Assistant Director of Student Services/ADA Coordinator. For more information, including filling out an application for services, please visit the SAR webpage at http://www.uttyler.edu/disabilityservices, the SAR office located in the University Center, # 3150 or call 903.566.7079.

Social Security and FERPA Statement:

It is the policy of The University of Texas at Tyler to protect the confidential nature of social security numbers. The University has changed its computer programming so that all students have an identification number. The electronic transmission of grades (e.g., via e-mail) risks violation of the Family Educational Rights and Privacy Act; grades will not be transmitted electronically.

Emergency Exits and Evacuation:

Everyone is required to exit the building when a fire alarm goes off. Follow your instructor's directions regarding the appropriate exit. If you require assistance during an evacuation, inform your instructor in the first week of class. Do not re-enter the building unless given permission by University Police, Fire department, or Fire Prevention Services.

Canvas for Students at UT Tyler

Getting Started:

1. Be sure to have a UT Tyler username. If you do not, please visit Passwords and Accounts (https://www.it.iastate.edu/services/accounts)
2. Login to Canvas with your UT Tyler username and password and look for your course for this semester.

General Help with Canvas:

In your Canvas course page, on the global navigation on the left panel, you will see a Help Tab. Clicking on that will take to various available options. Generally, you have:

- Canvas Live Chat – 24*7 live chat with Canvas specialists
- Canvas Guides-a repository of how-tos
- Ask the Canvas Community-Online support forum for canvas users.

Visit UT Tyler Canvas support if your questions are not answered