Sample Syllabus

ME 403 Polymer Electrolyte Fuel Cell Engines

Fall, 2016

Text: "Fuel Cell Engines", by M. M. Mench

Course URL: http://angel.psu.edu (logon and you will see the ME403 Webpage in your folder)

Prerequisites: Thermodynamics and Fluid Mechanics

Instructor: Dr. Donghai Wang, Associate Professor of Mechanical Engineering
E-mail dwang@psu.edu
Office: 134 MRL Building Phone: 863-1287
The best way to get me outside office hours is by e-mail.

Office Hours: M and W 1:00-2:00 pm and by appt. 134 MRL Building

COURSE DESCRIPTION:

This course serves as an introduction to the fundamental principles of electrochemistry applied to fuel cells, including an introduction to the thermodynamics and kinetics of electrode processes and mass transfer in electrochemical systems. The various types of fuel cell components and technologies are dissected in detail; with a vast majority of emphasis on the polymer electrolyte fuel cell systems includes direct inject alternative fuel systems. A survey of cutting-edge issues in fuel cell technology including the future direction of fuel cell technology will be presented if time permits. The student will also participate in a design project and visit a fuel cell research lab to aide in the understanding of these systems. Issues of specific interest to mechanical engineers, including water management and heat and mass transfer will be dealt with in greater depth.

WHO SHOULD CONSIDER:

This course is intended for the undergraduate or graduate engineering student interested in obtaining a fundamental background in the basic electrochemistry required for electrochemical system modeling and diagnosis. These fundamentals will be utilized to cover analysis of fuel cell systems with a special emphasis on polymer electrolyte fuel cell systems. Those students with interest in the basic design, operation, and characteristics of fuel cell systems should also benefit.

GRADING:

Normal Homework:	26%
MidTerm Exams:	30%
Lab session/related Homework:	24%
Design project:	20%
Class Partic.	3%
Late drops prior to first exam	-WN
Late drops after first exam:	
With a score ≥ 60%	-WP
With a score < 60%	-WF

Approximate cutoffs:
A: 90.0 – 100; A-: 87.0 - 89.9; B+: 83.0 – 86.9; B: 80.0 – 82.9; B-: 77.0 – 79.9; C+: 73.0 – 76.9; C: 70-72.9; D: 60.0 – 69.9; F: 59.9 and below.

OBJECTIVES: Upon completion of this course, students should be able to:

1. Apply fundamentals of electrochemistry, thermodynamics, fluid dynamics, and heat and mass transfer, as appropriate, to examine various issues of interest to mechanical engineers including electrode flooding, temperature, and species distribution.
2. Articulate the basic fundamentals of electrochemistry in terms of electrode processes, electrochemical potential, thermodynamics and kinetics of electrode reactions applicable to electrochemical systems.
3. Describe, explain, and model the various types of electrochemical overpotential occurring within the electrochemical system including ohmic, concentration, and activation overpotentials.
4. Describe, explain, and model the effects of mass transfer in electrochemical systems by migration, diffusion, and convection.
5. Describe and use Nernst equation to model cell EMF as a function of product and reactant activities.
6. Understand the meaning, use, and experimental derivation of the Tafel slope for determination of the transfer coefficient and the exchange current density.

7. Understand and use the Butler-Volmer model of electrode kinetics.
8. Understand the concepts and fundamentals behind basic experimental electrochemical methods used to determine various key parameters including, mass and ionic transport coefficients, exchange current density, and internal resistances.
9. Identify the main components, advantages, and limitations of gas-fed PEM, direct inject PEM,, molten carbonate, alkaline, phosphoric acid, and solid oxide fuel cell systems.
10. Apply basic software tools to the analysis of experimental data and mathematical models.
11. Work more effectively in groups to work through open-ended design problems.
12. Demonstrate professionalism, and respectful interaction with faculty and colleagues.

ACADEMIC DISHONESTY:

Academic dishonesty will not be tolerated ***at all***. I hope that everyone can develop enough pride in his or her own work and abilities that this will never be a problem. It is encouraged, however, to discuss problems solving techniques with classmates in study groups as long as each person does their own work. Absolutely no copying of homework/quizzes etc. will be tolerated. Evidence of academic dishonesty will be dealt with by University Policy 49-20, described at: http://www.psu.edu/ufs/policies/47-00.html#49-20

HOMEWORK FORMAT:

All homework should be in the following format, unless it is an open-ended question.

GIVEN: Include a sketch if possible.
ASSUMPTIONS: These need to be justified if they are atypical.
PROBLEM STATEMENT: What is unknown that we are asked to find.
SOLUTION: Solve the problem, step-by-step, and *always include units*. **Box the final answer.**
*****COMMENT*: At the end of each HW, you are required put in some brief comments to describe any thoughts or questions you have. This is your forum to ask questions, state opinions, and take some time to dig a little deeper into a problem than simple 'plugging and chugging'. There is no 'correct' answer. I will take a look and reply to them as needed. Examples; explain some interesting trend you noticed in a particular problem, what you liked/disliked about the HW or class periods, or pose a question to me. This is worth 3% of each HW grade.

Note: The most important thing to me is that the solution method is coherent and systematic. One of the major tools you should leave this course with is enhanced engineering problem solving methodology.

Homework schedules approximately every other week. Quiz will be announced before class.

PROJECTS:

There will be one group projects assigned during the course of the semester. The first project will be an experimental laboratory-based session(s), in which each group will be responsible for operating a real fuel cell and applying principles learned in class to analyze results. The project will expose the student to a practical lab environment. For this laboratory session, a group written report will be required. The second project will be based around an open-ended question that will require the teams to utilize the skills learned in class as well as in the fundamentals of mechanical engineering thermal science. The project will require students to design a fuel cell system for a particular application and perform multiple calculations to predict operational performance.

ATTENDANCE:

Due to the nature of this course and the fact that the quiz and test material will be discussed in class, it is assumed that those who regularly attend lectures will do better; therefore attendance is very important. Those who are habitually late or disruptive will forfeit the 2% class participation grade.

LATE HOMEWORK:

Homework turned in after the date due will have 15% taken off the grade per weekday it is late, with no exceptions.

HOMEWORK SOLUTIONS:

Will be put available on Angel.

CLASS NOTES:

The student version of electronically presented lectures will be available on the Angel web page. Due to the material covered, I will sometimes present overheads. *Every overhead presented in class will be available on Angel*.

WEB PAGE:

The course web page (http://angel.psu.edu) (logon and you will see the ME403 Webpage in your folder)) will provide updated information about schedule changes, course notes, HW assignments, grades, FAQs, exam/quiz reviews, links to useful sites, and contact information.

Anticipated Class Lecture Schedule

1: Introduction to Fuel Cells (1 wk)
2: Basic Electrochemical Principles (2 wks)
3: Thermodynamics of Fuel Cell Systems (3 wks)
4: Performance Characterization of Fuel Cell Systems (3 wks)
5: Transport in Fuel Cell Systems (2 wks)
6: Polymer Electrolyte Fuel Cells (2 wks)
7: Other Fuel Cells (1 wks)

ADDITIONAL INFO:

Penn State welcomes students with disabilities into the University's educational programs. If you have a disability-related need for reasonable academic adjustments in this course, contact the Office for Disability Services (ODS) at 814-863 1807 (V/TTY). For further information regarding ODS, please visit the Office for Disability Services Web site at http://equity.psu.edu/ods/.

In order to receive consideration for course accommodations, you must contact ODS and provide documentation (see the documentation guidelines at http://equity.psu.edu/ods/guidelines/documentation-guidelines). If the documentation supports the need for academic adjustments, ODS will provide a letter identifying appropriate academic adjustments. Please share this letter and discuss the adjustments with your instructor as early in the course as possible. You must contact ODS and request academic adjustment letters at the beginning of each semester.