ME 597D Advanced Topics in PEFCs Spring 2005

Text: Class notes and extensive review of relevant literature

Course URL: http://angel.psu.edu

Prerequisites: Grad Status or ME 497E "Fuel Cell Engines" or some relevant fuel cell background

Instructor: Dr. Matthew Mench, Assistant Professor of Mechanical Engineering
E-mail mmm124@psu.edu
Office: 327 Reber Phone: 865-0060
The best way to get me outside office hours is by e-mail.

Office Hours: After class, Thursday 1:00-2:00 and Friday 3:30-5:00, and by appt.

COURSE DESCRIPTION:

This course aims to deliver the graduate student to the cutting edge of understanding in Polymer Electrolyte Fuel Cell Science. The course will commence with a detailed review of PEFC fundamentals to lay a foundation of understanding for the rest of the class. Then, issues of high current interest will be discussed in the context of existing scientific literature. In each case, approaches for analytical and computational modeling and experimental validation will be discussed. Issues which will be discussed in depth include single and two-phase modeling, in situ and ex situ physical sensing and electrochemical experimental techniques, physiochemical modes of rapid and prolonged degradation, heat and water management, freeze/thaw behavior, fuel cell materials, the direct methanol and alternative alcohol fuel cells, and flowfield design.

WHO SHOULD CONSIDER:

This course is intended for the graduate engineering student with an understanding of polymer electrolyte fuel cells that is working toward a thorough understanding of the state-of-the-art in fuel cell science.

GRADING:

Projects/Quizzes	70%
Midterm (1)	20%
Class Partic.	10%
Late drops prior to first exam	-WN
Late drops after first exam:	
With a score $\geq$ 60%	-WP
With a score < 60%	-WF

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

1. Assimilate, distill, and disseminate current literature related to PEFCs at a professional level
2. Rapidly read and understand key literature and summarize with professional level oral and written communications.
3. 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, degradation ,etc.
4. Describe, explain, and model the various types of electrochemical overpotential and transport processes occurring within the electrochemical system including ohmic, concentration, and activation overpotentials.
5. Understand, develop and extend models describing heat and mass transport in PEFCs
6. Understand, develop and extend models describing various modes of rapid and prolonged degradation in PEFCs
7. Apply and extend the current available experimental in situ and ex situ techniques for fuel cell
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. Demonstrate professionalism, and respectful interaction with faculty and colleagues.

GOALS:

It is my goal to help each person enrolled in this class achieve the following things:

- A firm and complete understanding of the topics covered in this course, and an understanding of the relevant journals, authors, and literature available.
- An ability to quickly compile and deliver professional quality technical presentations and written summaries.
- An ability to understand and compile models that describe various phenomena covered in this course
- An experience in which the value added to the student in terms of education is long-lasting and transcends fuel cells. I want you to leave this class as better graduate students and engineers.

ACADEMIC DISHONESTY:

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

PROJECTS/QUIZZES:

There will be many short-term projects during the course of the semester that each student will have to complete. The projects will involve extensive review of relevant literature and class presentation.

MIDTERM:

There will be a written midterm in this class that will be take home in nature.

ATTENDANCE:

I have statistically proven that in my classes, those who regularly attend lectures will do better; therefore attendance is very important. Participation is 10% of the grade.

LATE ASSIGNMENTS:

You will be on time with all assignments.

CLASS NOTES:

I will post everything possible on Angel

The DRAFT AGENDA! Subject to *Massive* Upheaval

Lecture	Topic
1	**Introduction/PEFC, DMFC, and DAFC, Morphology of the catalyst layers and materials/ PEFC materials**
2	**Efficiency in Fuel Cells/ Fuel cell systems overvoltages and losses- The polarization curve**
3	**Modeling the Kinetics of Electrochemical Reactions/ The Double Layer**
4	**Modeling the Kinetics of Electrochemical Reactions/ The Double Layer**
5	**Ohmic Losses-proton transport mechanisms/Concentration Polarization – gas and liquid phase transport**
6	**Midterm – Fuel Cell Fundamentals**
7	**Topic #1 Computational Modeling – single phase modeling approaches to PEFC**
8	**Topic #1 Computational Modeling – single phase modeling approaches to PEFC**
9	**Presentations on CFD models (single-phase)**
10	**Topic #2 Experimental Methods – *in situ* techniques**
11	**Topic #2 Experimental Methods – electrochemical analysis methods and laser-based diagnostics**
12	**Presentations on Experimental methods**
13	**Topic#3 Heat and Water Management- Models**
14	**Topic#3 Heat and Water Management- Experimental studies and analysis**
15	**Presentations on Heat and Water Management**
16	**Topic #4 Degradation in PEFCs – Slow modes of degradation**
17	**Topic #4 Degradation in PEFCs – Rapid Modes of degradation and poison**
18	**Presentations on Degradation in PEFCS**
19	**Topic #5 Freeze/thaw in PEFCS – problem definition and available literature.**
20	**Presentations on Freeze/thaw in PEFCS**
21	**Topic #6 Flowfield design – types available and relative trade-offs**
22	**Topic #6 Flowfield design – what do we expect?**
23	**Presentations on flowfield design**
24	**Topic #7 The DMFC – Issues and performance**
25	**Topic #7 The DMFC – Modeling and Key Studies**
26	**Presentations on DMFC**
27	**Topic #8 Alternative PEFCS – types available and relative trade-offs**
28	**Topic #8 DAFCs, Formic acid, Biological fuel cells, DME and other**
29	**Presentations on Alternative PEFCs**

STATEMENT ON ACADEMIC INTEGRITY

It is a simple matter of personal integrity, but unfortunately there are a few out there that have no personal pride in their own work. Earning a C is far more satisfying than stealing an A. Academic honesty and integrity is of utmost importance. Detailed information on this topic can be found at www.engr.psu.edu/undergrad/acad_int/students. Some examples are given below:

CHEATING: **Using crib sheet; pre-programming a calculator; using notes or books during a closed book exam etc.**
COPYING ON TEST: **Looking at another unsuspecting student's exam and copying; copying in a complicit manner with another student; exchanging color-coded exams for the purpose of copying; passing answers via notes; discussing answers in exam, etc.**
PLAGIARISM: **The fabrication of information and citations; submitting others work from professional journals, books, articles and papers; submission of other students papers or lab results or project reports and representing the work as one's own; fabricating in part or total, submissions and citing them falsely, etc.**
ACTS OF AIDING OR ABEADING: **Facilitating acts by others; unauthorized collaboration of work; permitting another to copy from exam; writing a paper for another; inappropriately collaborating on home assignment or exam without permission or when prohibited, etc.**
UNAUTHORIZED POSSESSION: **Of examinations, through purchase or supply; stealing exams; failing to return exams on file; selling exams; photocopying exams; buying exams; any possession of an exam without the custodian's permission, etc.**
SUBMITTING PREVIOUS WORK: **Submitting a paper, case study, lab report or any assignment that had been submitted for credit in a prior class without the knowledge and permission of the instructor.**
TAMPERING WITH WORK: **Changing own or another students work product such as lab results, papers, or test answers; tampering with work either as a prank or in order to sabotage another work, etc.**
GHOSTING: **Taking a quiz, an exam, performing a laboratory exercise or similar evaluation in place of another; having another take a quiz, an exam, or perform an exercise or similar evaluation in place of the student, etc.**
ALTERING EXAMS: **When instructor returns graded exams for in class review and subsequently collects them, student changes incorrect answers and seeks favorable grade adjustment asserting that instructor made mistake in grading; other forms may include changing the letter or and/numerical grade on test; obtaining test in discretely, etc.**
COMPUTER THEFT PROGRAM: **Electronic theft of computer programs, data, or text belonging to another etc.**