

**CHE 494/598 and CEE 598**  
**Fuel Cells and Biofuel Cells**  
**Fall 2013**

<b>Credits:</b>	<b>3</b>
<b>Prerequisites:</b>	CHM116 or equivalent, Junior/Senior in Engineering
<b>Class Time:</b>	Tue and Thu: 10:30- 11:45 a.m.
<b>Class Location:</b>	CPCOM213
<b>Instructor:</b>	César I. Torres
<b>Office:</b>	GWC 548
<b>Instructor E-mail:</b>	<a href="mailto:cit@asu.edu">cit@asu.edu</a>
<b>Office Hours:</b>	Mon 11:00am-noon, Tue noon -1:00 pm, and by appointment
<b>Required Text:</b>	Fuel Cell Fundamentals 2 <sup>nd</sup> Edition by O'Hayre, Cha, Colella, Prinz
<b>Additional Texts:</b>	Fuel Cell Handbook 7 <sup>th</sup> edition by US Department of Energy (online) Various papers on biofuel cells and microbial fuel cells
<b>Course Web Page:</b>	Blackboard at MyASU.

**Course Overview:** This class provides a comprehensive analysis of fuel cell technologies. We will begin by discussing the different types of fuel cells and the thermodynamic and kinetic fundamentals that control their performance. Then, we will discuss materials and techniques used to characterize fuel cells. We will finish the course with a specific analysis of biofuel cells and their applications.

**Grading:**

- **25% Homework Assignments**
  - Homework will be assigned based on the topics discussed.
  - Homework assignments are due in class on their due date, no exceptions. Late assignments will carry a penalty of 10% per day.
  - All assignments are due the Tuesday after they are posted.
  - There will be 4 homework assignments.
- **10% Journal Club/Class Participation**
  - Students will participate in the discussion of a journal paper related to the class topics. Students will be in charge of explaining figures/tables from the paper.
- **30% Midterm Exam**
  - Tentatively on October 31<sup>th</sup>, covering Chapters 1-5, 7.
- **35% Final Review/Analysis Paper (30%) and peer editing/review (5%)**
  - A final paper will be assigned in groups of 4. The paper will focus on a topic discussed in class and will contain a review of literature and analysis of data reviewed. Progress reports will be required throughout the latter part of the semester, as outlined below.

**Academic Integrity:** Academic dishonesty will not be tolerated. Please see the Student Code of Conduct set forth by the Arizona Board of Regents. This includes copying of homework. You are encouraged to discuss the homework problems with your classmates, but the final work that is turned in must be your own. Exams will solely be individual efforts. Students are expected to abide by the ASU Student Code of Conduct and Academic Integrity Policy ([http://www.asu.edu/studentaffairs/studentlife/judicial/academic\\_integrity.htm](http://www.asu.edu/studentaffairs/studentlife/judicial/academic_integrity.htm)).

### Additional Information:

1. Collaboration is acceptable for completing the homework assignments. However, it is expected that you will *do your own work* on each problem. ***Each student must complete all parts of the problem on their own.***
2. Students are required to be on time for class and not distract the fellow classmates or the instructor. Talking during class, as well as the use of cell phones, pagers, etc., is prohibited. If you need to make or take a call, you can leave the classroom, making sure you do not disturb the class.
3. Make sure to take advantage of office hours. I cannot make sure that every student understands the material given in every class. If you did not understand the material, come talk to me and I will do my best to explain.
4. I will use a standard grading curve, I do plan to use a limited +/- system as follows:

A+: > 97%	A-: 89.5 - 91%
B+: 87.5 - 89.4%	B-: 79 - 81%
C+: 77-78.9%	There is no C-

### Instructions for Final Paper Submission/Presentation:

The class will be divided in groups of 3 or 4 to write a final paper and review/edit other papers on topics related to the class. The topics will be chosen by the group and discussed and approved by the Instructor. The purpose of the final paper is to review and analyze a specific topic related to fuel cells. The instructor will provide examples of previous topics in order to guide the teams in selecting their own topic. The paper will contain the following:

- Title Page including abstract. The abstract should be no longer than 300 words and is included on the title page, which also includes the Title and group member names on Top. This page should be written in 12-point Times New Roman, single space document with 1" margins on all sides.
- Main document- 8-12 pages long, 12-point Times New Roman, single space document with 1" margins on all sides. New figures or borrowed figures (from other publications) are allowed and encouraged, inserted at a reasonable size. Be judicious on the number and type of figures borrowed.
- List of references – A minimum of 12 references are required, although the document should contain more than 20 references. The references should be formatted according to the journal *Biotechnology and Bioengineering*. Here are two examples, one for a journal paper and one for a book:

Marcus AK, Torres CI, Rittmann BE. 2007. Conduction-Based Modeling of the Biofilm Anode of a Microbial Fuel Cell. *Biotechnol Bioeng* 98:1171–1182.

Bard AJ, Faulkner LR. 2001. *Electrochemical methods: Fundamentals and applications*. 2nd edn. New York: John Wiley.

Teams will be formed by the end of the fourth week of class. We will follow the following schedule:

- Sept 19 – Group submits at least two topics for the final paper. The instructor will provide feedback on the best topics.
- Oct 3 – Group provides an outline of the paper, based on the topic selected, with specific sections that will be covered.
- Oct 18 – Class discussion on topics and outlines. Feedback is provided by instructor and students.
- Oct 24 – First draft of the paper (at least 3 pages), focusing on the literature review. Provide an outline for missing sections.
- Nov 21 – Second draft of the paper, should be close to the final version. Each student will read another paper to edit and review.
- Nov 26, Dec 3,5 – Teams give a 10-15 min presentation on the paper in class.
- Dec 10 – Deadline to submit final paper.

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### Preliminary Course Outline and Schedule

Note: The schedule is subject to change but gives a general idea on the course content.

Class date	Subject	Reading	Journal Clubs	Homework Posted*	Final Paper
8/22	Introduction	Ch 1			
8/27-8/29	Introduction/FC Types	Ch 1, 8			
<del>9/3</del> -9/5	FC Thermodynamics	Ch 2			
9/10-9/12	FC kinetics/ Thermodynamics	Ch 2, 3		HW#1 – 9/10	Teams are formed
9/17-9/19	FC Kinetics	Ch 3		HW #2 – 9/19	9/19 Topics are proposed
9/24-9/26	Charge transport	Ch 4	JC#1-9/24		
10/1-10/3	Mass Transport	Ch 5	JC #2 – 10/1	HW #3 – 10/3	Paper Outline – 10/3
10/8-10/10	FC Characterization	Ch 7	JC #3 – 10/8		
<del>10/15</del> -10/17	FC Characterization	Ch 7	JC #4 – 10/17	HW#4 – 10/17	
10/22 – 10/24	FC Materials/ Midterm Review	Ch 7			Draft #1 – 10/24
10/29 – 10/31	FC Materials	Ch 9		<b>Midterm 10/31</b> (Ch 1-5, 7)	
11/5 – 11/7	Draft 1 discussion/ Enzymatic FCs	Handouts	JC #5 – 11/5		
11/12 – 11/14	Enzymatic/ Microbial FCs	Handouts	JC #6 – 11/12		
11/19 – 11/21	Microbial FCs	Handouts	JC#7-11/21		Draft #2 – 11/21
11/26 – <del>11/28</del>	Group Presentations	Handouts		Thanksgiving Break	
12/3 – 12/5	Group Presentations				
12/10		--			Final Paper Submission

Abbreviations: FC: Fuel Cell, JC: Journal Club, HW: Homework assignment posted

\*Note that dates are for the HW posting, not the date you turn them in. HW assignments will be due Tuesday after they are posted.