I. Course Identity, Teaching Staff, and Logistics

Instructor: New hire or Prof. Shannon Boettcher, email: swb@uoregon.edu, office: 435 LISB, Phone: 541-346-2543

Office hour: There will be two office hours per week. The times will be determined on the first day of lecture based on student availability.

Format: Laboratory

Credits: 4

Location: Required laboratory hours, Monday/Wednesday 2:00 pm – 4:50 pm, will meet in the Oregon Center for Electrochemistry (Tentatively Onyx 372).

Required course materials:


Kinder. A student's guide to Python for physical modeling, 2018.

Additional course materials:

The following texts are used in the lecture electrochemical engineering course. They are not required for this course, but students will find the content useful for completing the laboratory projects.


Course website: Laboratory Project Assignments, lecture notes, videos, and grades will be posted on the Canvas course site.

Prerequisites: Advanced Electrochemistry CH454/554.

Co-requisite: Electrochemical Device Engineering CH692
II. Course Description

In CH692 students learn how electrochemical devices operate and the engineering principles behind them. In this course, CH693, students apply those concepts in a laboratory setting to develop a hands-on practical understanding of device fabrication and testing. Students will work in small teams to build Li-ion battery devices, electrolyzers for the production of chemicals and/or fuels, fuel cells, and biosensors. They will test the performance and response of these devices compared to theory and modelling, applying experimental design and statistical analysis methods. Open-ended laboratory projects will include those focused on electrodeposition and corrosion where students will be required to apply electrochemical science and engineering principles to solve a defined challenge without specific step-by-step guidance. An open-ended laboratory project is where students are given the freedom to develop their own experiments, instead of following already set guidelines. Student will meet two afternoons a week (3 h each) for mandatory laboratory/group-discussion sessions led by the instructor and/or teaching assistant. Open laboratory times will also be established for students to work at their own pace and on their own schedule on the assigned projects, after appropriate safety training and with oversight as needed. Feedback from industry partners will drive laboratory project content evolution.

III. Expected Learning Outcomes

- Learn the practical approaches and techniques needed to construct electrochemical devices
- Learn the measurement techniques and how to use electrochemical instrumentation to characterize electrochemical devices.
- Learn to apply foundational concepts in chemical thermodynamics, kinetics, and mass transport to analyze the operation and performance of practical electrochemical devices
- Learn to use data collected in the laboratory to drive system optimization
- Learn to find and assess the primary literature to drive laboratory decision making.

IV. Estimated Student Workload

Course participants will attend laboratory sessions, perform assigned reading, attend open laboratory times and collect data, analyze data, and write professional quality reports. The table below shows the estimated workload.

<table>
<thead>
<tr>
<th>Activity</th>
<th>Estimated hours per term</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory Project Report</td>
<td>40</td>
<td>6 project reports, typically 10 pg. with data per report</td>
</tr>
<tr>
<td>Preparation Literature Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open Laboratory Time</td>
<td>60</td>
<td>Estimated at 6 h / week</td>
</tr>
<tr>
<td>Mandatory Laboratory Sessions</td>
<td>60</td>
<td>6 h / week</td>
</tr>
<tr>
<td><strong>Total hours:</strong></td>
<td><strong>160</strong></td>
<td></td>
</tr>
</tbody>
</table>
V. How Grades Will Be Determined

The grades will be determined based on the following percentage breakdown of the final total score:

**Professionalism and safety in the laboratory setting - 10%**
**Quality of laboratory project reports; data, analysis, and discussion – 90%**
No final or midterm exam

Projects will be graded based on the quality of the project report. Reports are expected to be concise formal documents with professional quality graphs (including appropriate use of units and error estimates) and data analysis, and insightful discussion of the data (~10 pages for each). Each project assignment is accompanied by a document outlining project expectations.

**A** = Clearly written, concise document, with high-quality figures. All required pieces of data are shown and discussed without major errors in the interpretation. Project reports (1) use laboratory data in quantitative and specific ways to support conclusions, (2) make comparisons to theory/expectations where possible, and (3) show mastery of the principles underlying the operation of common electrochemical devices.

**B** = One or more issues with the items above.

**C** = Multiple issues with quality of the written document and interpretation/discussion.

**D** = Multiple issues and incomplete.

+/- grades will be applied consistent with the above criteria. A+ will be given for near-perfect reports with high quality data.

A+ course grades will be given to the top-performing students in the course, provided they reach >95%. Students earning >90% in the course will earn at least and A, > 80% at least a B, >70% at least a C, and >60% at least a D. The instructor may curve the course to increase the letter grades for a given percentage score to account for variations in difficulty of the exam questions from year-to-year. Students with a given percentage score will not, however, earn a grade lower than that indicated above.

VI. Course Schedule and Assignments

**Assigned reading:** Weekly reading from Fuller and Harb given after each topic. Reading should be started prior to the start of the weekly lectures and completed before the start of the following weeks lectures. Problem Sets are due on the 2nd lecture of the week following their assignment.

**Week 1**
**Laboratory Meeting 1:** Laboratory Safety Review
Laboratory Meeting 2: Training, Introduction to Electrochemical Equipment and Software  
Reading: Laboratory Safety Manual.

**Week 2**
Laboratory Meeting 1: Laboratory project 1: Li-ion battery design, fabrication, testing, module design, and post-mortem failure analysis.
Laboratory Meeting 2: Continue laboratory project 1
Reading: Selected primary current primary literature. Fuller and Harb Chapter 7: Battery Fundamentals (pg. 151-169).

**Week 3**
Laboratory Meeting 1: Continue laboratory project 1
Laboratory Meeting 2: Project 2: Fuel Cell design, fabrication, testing, module design, and post-mortem failure analysis (proton exchange membrane, alkaline exchange membrane).
Reading: Chapter 9: Fuel Cell Fundamentals (pg. 195-216)

**Week 4**
Laboratory Meeting 1: Continue laboratory project 2  
Laboratory Meeting 2: Continue laboratory project 2
Reading: Relevant primary literature for specific project (each team will be assigned a different materials aspects of fuel cell systems).
Project 1 Due.

**Week 5**
Laboratory Meeting 1: Continue laboratory project 2
Laboratory Meeting 2: Project 3: Electrochemical Double Layer Capacitor: Carbon and Electrolyte Engineering, Pseudocapacitance, Rate Optimization, Cell Packaging.
Reading: Relevant primary literature for specific project (each team will be assigned a different materials aspects of capacitor systems).

**Week 6**
Laboratory Meeting 1: Continue laboratory project 3.
Laboratory Meeting 2: Continue laboratory project 3.
Reading: Relevant primary literature for specific project (each team will be assigned a different materials aspects of capacitor systems).
Project 2 Due.

**Week 7**
Lecture 2: Continue project 4.
Reading: Chapter 14: Industrial Electrolysis, Electrochemical Reactors (pg. 323-350)
Project 3 Due.
Week 8
Laboratory Meeting 1: Continue laboratory project 4.
Laboratory Meeting 2: Continue laboratory project 4.
Reading: Current primary literature relevant to selected materials system.

Week 9
Laboratory Meeting 1: Project 5: Electrodeposition of Metals: Controlling Nucleation and Growth for Conformal High-Density Coverage
Laboratory Meeting 2: Continue Project 5
Reading: Fuller and Harb, Chapter 13: Electrodeposition (pg. 299-319). Relevant electrodeposition primary literature for specific team project (Each team will be assigned a different system to study, understand, and optimize. Each team will identify the key publications).
Project 4 Due.

Week 10
Laboratory Meeting 1: Corrosion: Project 6: Corrosion of Industry Relevant Materials: Standard test procedures, analysis, and prevention
Laboratory Meeting 2: Continue Project 6
Reading: Fuller and Harb, Chapter 13: Electrodeposition (pg. 299-319). Relevant corrosion primary literature for specific team project (each team will be assigned a different system to study, understand, and optimize and identify the key publications).
Project 5 Due.

Finals Week

Wednesday: Project 6 due.

VII. Course Policies

- Late or missed work will not generally be accepted without prior approval.
- Project reports must be your own work. You may share data across the class if it strengthens the quality of the report but the analysis and discussion of the data in the report must be your own work.
- There will be a zero-tolerance policy for plagiarism in laboratory reports.
- Academic Misconduct: The University Student Conduct Code (available at conduct.uoregon.edu) defines academic misconduct. Students are prohibited from committing or attempting to commit any act that constitutes academic misconduct. By way of example, students should not give or receive (or attempt to give or receive) unauthorized help on assignments or examinations without express permission from the instructor. Students should properly acknowledge and document all sources of information (e.g. quotations, paraphrases, ideas) and use only the sources and
resources authorized by the instructor. If there is any question about whether an act constitutes academic misconduct, it is the students’ obligation to clarify the question with the instructor before committing or attempting to commit the act. Additional information about a common form of academic misconduct, plagiarism, is available at https://researchguides.uoregon.edu/citing-plagiarism.

- Accessibility: The University of Oregon is working to create inclusive learning environments. Please notify me if there are aspects of this course that result in disability related barriers to your participation. For more information or assistance, you are also encouraged to contact the Accessible Education Center, Suite 360 Oregon Hall, 346-1155 or uoaec@uoregon.edu; website: http://aec.uoregon.edu/content/about

- A graduate employee (GE) will serve as a teaching assistant for this course. The GE’s responsibilities will include assisting in the implementation of the project component of the course, including supervising students completing the projects and obtaining/distributing materials needed for the project. The GE may assist with grading, and will also be available for general assistance in preparing project reports, completing homework assignments, and preparing for exams. Should graduate students enrolled in the course perceive the course as leading to any conflict of interest, privacy concerns, or unfairness related to having a GE in the above role please contact the instructor to discuss paths of recourse. If the GE is involved in grading assignments, graduate students may request that a faculty member, not the GE, grade their assignments. To do this please make the request in writing via email to the instructor.