

Stanford University Department of Civil & Environmental Engineering

Syllabus

CEE273C Environmental Engineering Applications of Membrane Technology

3 units; Summer 2016

Lecturer: Martin Reinhard (reinhard@stanford.edu)

Weekly Schedule: Fridays 1:30 pm - 5:20 pm

Location: Y2E2 111

Grading: Letter or Credit/No Credit

Assignments: Each student writes a 6-page paper and makes an oral presentation.

Overview: Introduction to membrane technology and processes with applications in R&D, water/wastewater treatment, and renewable energy. Membrane separation principles, reverse osmosis, nanofiltration, membrane characterization techniques, mass transport phenomena, fouling processes, rejection of salts and trace organics, brine disposal system design, energy and cost considerations, and pre- and post-treatment procedures. Case studies in environmental sustainability issues related to full scale treatment engineering.

Requirements: Current standing as a graduate student. Undergraduate juniors and seniors are required to obtain consent of instructor to enroll.

Teaching goals

- Equip students with the basic understanding of membrane processes and their application in water treatment.
- Designing a reverse osmosis system using a commercial software package.
- Reading original literature of current research topics.

Topics & Term Schedule

Week #	Date	Topics	Homework
1	6.24	Introduction Water treatment by conventional and advanced membrane technology: seawater, brackish and surface water and wastewater, fields of application outside water technology. Basics Low-pressure applications, membrane bioreactors (MBR). Low and high-pressure membrane filtration: overview of membrane types and applications, theory and concepts, terminology. Pressure and energy requirements. The thermodynamics of osmotic pressure, concentration polarization, trans-membrane and osmotic pressure, dead-end and filtration.	Select paper topic

2	7.1	<p>Membrane treatment technology Membrane synthesis, flat sheet cells, spiral-wound elements and hollow-fiber tubular) membrane systems. Membrane morphology. Concentration polarization. Transport models: solution-diffusion and pore-flow. Salt removals. Relationship of pore-size and selectivity. Molecular size cutoff, organic contaminant removals, property-removal relationship.</p>	Title of paper due
3	7.8	<p>Processes at the membrane surface Chemical and biological fouling. Bad actors in membrane fouling: bacteria and biofilms, exocellular polymers, scaling due to salt precipitation, organics adsorption, cake-formation.</p> <p>Fouling mitigation Membrane cleaning, pretreatment and disinfection. Operational considerations: cleaning intervals, cleaning solutions, disinfectants, damage to membrane structure. Post-treatment: advanced oxidation.</p>	Outline of paper due
4	7.15	<p>System design Arrangement of modules. Integration of membrane treatment systems. MBR performance and MBR-RO combinations. Membrane specifications. System Design: the use of modeling software.</p>	Draft #1 due
5	7.22	<p>Membrane system operation Water quality considerations: biological, organic and salt concentrations. Case studies: Orange County, California, Israel. Topics of current research: forward osmosis.</p>	Draft #2 due
6	7.29	<p>Sustainability Energy, environmental impacts and cost considerations, energy recovery. Brine management, outlook on desalination.</p>	
7	8.5	Presentations.	
8	8.9	No class meeting.	Final Paper Due.

Collaboration & The Stanford Honor Code

Students are expected to adhere to the Stanford Honor Code (<http://studentaffairs.stanford.edu/judicialaffairs/policy/honor-code>) which describes standards of acceptable and unacceptable student conduct. Of particular importance are the rules regarding receiving aid that is not explicitly permitted in exams and class work.

It is also important that students take an active part in seeing that the letter and spirit of the Honor Code are upheld by themselves and others.

It is OK to ask a fellow classmate for clarification on a problem or direction on its solution after a good faith effort. However, wholesale copying is strictly forbidden. Each student is responsible for handing in solutions to their homework and it should reflect their own understanding of the material and work. If you receive any significant help on an assignment or particular problem, you are required to document this assistance and who provided it to you.

Also of importance in these days of the ubiquitous Internet are the explicit prohibition of plagiarism. Penalties for violation of the Honor Code can be serious (e.g., expulsion from the University).

Students with Documented Disabilities

Students who may need an academic accommodation based on the impact of a disability must initiate the request with the Office of Accessible Education (OAE). Professional staff will evaluate the request with required documentation, recommend reasonable accommodations, and prepare an Accommodation Letter for faculty dated in the current quarter in which the request is being made. Students should contact the OAE as soon as possible since timely notice is needed to coordinate accommodations. (<http://oae.stanford.edu>).