

# Course Syllabus

CEE 648 - Spring 2016

## MEMBRANE SEPARATIONS IN AQUATIC SYSTEMS

### Objective

- To study fundamental and applied aspects of conventional pressure-driven membrane filtration technologies: Microfiltration (MF), Ultrafiltration (UF), Nanofiltration (NF), and Reverse Osmosis (RO), and the state-of-the-art energy-efficient membrane processes: Forward Osmosis (FO), Pressure-retarded Osmosis (PRO), and Membrane Distillation (MD). When available, special topics include Ocean Thermal Energy Conversion (OTEC), Adsorption Desalination (AD), Electrodialysis (ED) and Reverse Electrodialysis (RED).

### Course Schedule:

Lecture Friday, **9:00 a.m. – 11:45 a.m.**, Don Kim lab, POST 214

### Instructor:

PROF. ALBERT S. KIM

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URL: <http://albertsk.org>  
Office Hours: Monday - Wednesday, as needed or by appointment

### Texts:

- Main Text: Instructor's handouts
  - Course specific handouts will be distributed to students.
- Supplementary Textbooks and Reading Materials:
  1. **Sustainable Water for the Future: Water Recycling versus Desalination**, eds.: Isable Escobar, Andrea Schafer, Elsevier, 2010.
  2. **Basic Principles of Membrane Technology**, 2nd Ed., by Marcel Mulder, Kluwer Academic Publishers, 2000.

3. **Membrane Technology and Applications**, 2nd Ed., by Richard W. Baker, John Wiley & Sons, 2000.
4. **Water Treatment Membrane Processes**, by American Water Works Association Research Foundation, McGraw-Hill, 1996.
5. **Microfiltration and Ultrafiltration**, by Leos J. Zeeman and Andrew L. Zydney, Marcel Dekker, Inc., 1996.

## Grading:

Class Participation + Attendance	15 %
Quizzes	5 %
Homework (~12)	20 %
Midterm	30 %
Final	30 %

## Homework and Quizzes:

- Homework will be assigned on a weekly schedule. Late homework will not be accepted (unless this is an officially excused absence).
- There will be several quiz tests during the semester. Missed quizzes may not be made up (unless this is an officially excused absence).
- Submit your homework using Google Drive with file name of "**CEE648S16-HW01-LastName-FirstName.doc**" (no spaces in the file name at all). Change the homework number as needed. Share your homework files in your Google Drive to me (albertsk@gmail.com), and I should be able to view and **edit** your homework files. HW grading will be online.

## Study Topics and Schedule

1. [1/15] Introduction and Overview
  - History, classification and applications, driving force and performance evaluation, membrane structures and modules
2. [1/22] Global water scarcity
  - Global demand of water and energy, desalination vs. reuse, and membrane vs. thermal processes.
3. [1/29] Thermodynamics and Transport Phenomena (I)
  - Basic thermodynamics, ensembles and energy functions, and transport phenomena

4. [2/05] Thermodynamics and Transport Phenomena (II)
  - Advanced thermodynamics (statistical mechanics for membrane separation)
  - Basic mass/heat/momentum transfer
5. [2/12] Reverse Osmosis and Nanofiltration (I)
  - Basic RO modeling using solution-diffusion model, concentration polarization, and advanced models
6. [2/19] Reverse Osmosis and Nanofiltration (II)
  - Empirical correlations for mass transfer, fouling phenomena, and array design
7. [2/26] Forward Osmosis
  - Introduction to FO, fundamental transport phenomena of FO vs. RO, and FO applications and future directions.
8. [3/04] Pressure-Retarded Osmosis
  - Comparative analysis of RO, FO, and PRO and application potential
9. [3/11] Microfiltration and Ultrafiltration
  - Transport in porous media and filtration models
10. [3/18] Thermodynamics and Transport Phenomena (III)
  - Thermal phase change, vapor pressure, latent heat, and combined diffusion
11. [4/01] Membrane Distillation (I)
  - Transport mechanisms, membrane materials and properties
12. [4/08] Membrane Distillation (II)
  - Operation modes: direct contact, vacuum, sweep gas, air gap, and liquid gap MD
13. [4/15] Electrodialysis and Reverse Electrodialysis
14. [4/22] Special topics: Ocean thermal energy conversion (OTEC) and adsorption desalination (AD)
15. [4/22] Special topics and/or course review
16. [5/6] Final exam (the last day of instruction: 5/3)