CEE 648 Membrane Separations

1 Course Description

1.1 In Catalog

Applications of membrane separations to desalination, power generation, and ultrapure water systems. Discussion of reverse osmosis, osmosis-driven processes, ultrafiltration, microfiltration, electrodialysis, and ion exchange technologies. Membrane fouling and concentration polarization from practical/theoretical standpoints. A-F only. Pre: 635 or consent.

1.2 Details

Fundamental and applied topics of novel and standard membrane filtration include pressure-driven processes of microfiltration (MF), ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO)); state-of-the-art (hybrid) separation processes of forward osmosis (FO), pressureretarded osmosis (PRO), and membrane distillation (MD); and emerging desalination processes of freezing desalination (FD) and interfacial evaporation (IE). Basic theories for mass, energy, and momentum transport will be covered as needed.

2 Learning Objectives

Students obtain capabilities to

- know the current state-of-the-art membrane separations, especially for desalination
- understand fundamental sciences governing the membrane separation processes
- apply the learned skills for designing membrane processes and plants.
- identify the efficient and sustainable membrane processes for specific needs
- design novel membrane processes using geographic advantages
- develop holistic engineering strategies, dealing with public perception.
- evaluate the present and future separation processes under the net-zero emission, zero-discharge limit, global warming/boiling, climate crisis, and sea-level rise.

3 Instructor

Instructor	Prof. Albert S. Kim
Office	POST 203C
Phone:	956-3718
Email:	albertsk@hawaii.edu
Course URL:	Laulima and Google Classroom (class code: TBA)
TA (grader)	None
Office hours	TBA, Shortly after each class or by appointment

4 Grading

Items	Percentage (%)	Achievement	Grade
Online activity	10	90 – 100 %	A
Homework	10	76 – 90 %	B
Midterm 1	25	65 – 76 %	C
Midterm 2	25	50 – 65%	D
Final	30	$< 50\%$	F

5 Lectures

- Date and time: TBA or asynchronous
- Location: Online
- Textbook: Instructor's handouts and journal papers

6 Class Schedule

Exams are not accumulative as their chapters are indicated in the list below.

1. WK01 Introduction and Fundamental Review
    - WK01A Global Water Scarcity
    - WK01B Coupled Transport of Mass, Energy, and Momentum
2. WK02 Microfiltration (MF) and Ultrafiltration (UF)
    - WK02A Principles and Phenomena
    - WK02B Principles and Phenomena
3. WK03 Microfiltration (MF) and Ultrafiltration (UF), cont'd
    - WK03A Empirical correlations for k_f
    - WK03B Practical Point of View
4. WK04 Membrane Thermodynamics (MTh) I
    - WK04A Thermodynamic Phenomena and Analysis
    - WK04B Themodynamic Variables and Ensembles
5. WK05 Reverse-Osmosis and Nanofiltration I

- WK05A Principles and Phenomena
- WK05B Membrane Transport Models for RO/NF

6. WK06 Reverse-Osmosis and Nanofiltration II
   - WK06A RO/NF Process Modeling
   - WK06B Design and Applications
7. WK07 Exam and Supplementary Lecture
   - Midterm-I
   - Review MT1
8. WK08 PressureRetarded Osmosis (PRO)
   - Concentration gradient as energy source
   - Gibbs energy and power generation
9. WK09 Forward Osmosis (FO)
   - Fundamental concepts and balance equations
   - Process design and performance
10. WK10 Membrane Thermodynamics II
    - Advanced Thermodynamics for Membrane Separations
    - Basic Statistical Mechanics for Phase Change
11. WK11 Membrane Distillation (MD)
    - Separation using Phase Change
    - MD Principles and Types
12. WK12 Mid-semester Review and MT-II
    - Review and Problem Solving
    - Midterm-II
13. WK13 Membrane Distillation (MD) \ Interfacial Evaporation (IE)
    - Fundamentals of interfacial evaporation
    - Interfacial evaporation process analysis
14. WK14 Freezing Desalination (FD)
    - Fundamentals of Freezing Thermodynamics
    - Literature Review of Freezing Thermodynamics
15. WK15 Freezing Desalination (FD)
    - Desalination by Freezing Seawater
    - Modeling Freezing Desalination
16. WK16 Course Review and Problem Solving
    - Course Review and Process Integration

7 Notes and Rules

- Homework will be assigned on a daily basis and cumulatively due Fridays.
- There will be three exams, and specific times and formats will be announced.
- Students' homework *should contain* proper figures, diagrams, procedures, and/or enough detailed explanation and should be very well organized in a logical flow.
- Homework must be submitted fully online using Google Classroom. The file name should have a standard format of, e.g., CEE648_HW##_LastName_First.docx, e.g. **CEE648_HW01_Kim_Albert.docx**. No spaces and special characters should included in file names.
- Students do not need to type any mathematical derivations using the Equation Editor or MathType in MS Word files unless you really want to for your own record. But, students' hand-writing should be eligible although hand-written derivation procedures are enough to get credits.