جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Membrane Sc. and Membr. Separation Proc. - CBE 336

Division	Physical Science and Engineering Division
Course Number	CBE 336
Course Title	Membrane Sc. and Membr. Separation Proc.
Academic Semester	Spring
Academic Year	2017/2018
Semester Start Date	01/28/2018
Semester End Date	05/24/2018
Class Schedule (Days & Time)	02:30 PM - 04:00 PM | Sun Wed

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Ingo Pinnau	ingo.pinnau@kaust.edu.sa	+966128082406		By appointment only. Please send a request at least two days prior to the office appointment per e-mail (ingo.pinnau@kaust.edu.sa) or after each course lecture.

Teaching Assistant(s)

Name	Email
N/A	N/A

Course Information

Comprehensive Course Description	The course will cover all basic principles of membranes science and the corresponding membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas permeation). A brief introduction on the historical development of membranes and membrane processes will be given. Membrane structures and their functionalities developed for specific processes will be covered. The transport principles for porous and non-porous membranes (viscous flow, Knudsen diffusion, Fick's law, solution/diffusion) will be discussed in great detail with respect to their driving forces and how this knowledge can be applied to design advanced membrane materials/structures. Furthermore, this knowledge is essential in identifying technical limitations of membrane processes in their practical and economic use. A large fraction of the course will be dedicated to materials sciences aspects required for the development of advanced membranes for individual process types. A major fraction of the course will be dedicated to cover polymer membranes, including the synthesis of high-performance polymers, formation of integral-asymmetric and thin-film composite membranes, and hollow fiber technology. General analytical techniques to evaluate membranes will be introduced for reverse osmosis and gas permeation membranes, followed by a series of lab demonstrations in the Advanced Membranes and Porous Materials Center. The course will be concluded with a visit to the 40,000 m3/day seawater reverse osmosis plant and the wastewater plant at KAUST.
Course Description from Program Guide	Formulation and solution of engineering problems involving design of membrane systems for gas separation, reverse osmosis, filtration, dialysis, pervaporation and gas absorption/stripping processes. Membrane selection, fabrication and preparation. Membrane transport: gas permeation and reverse osmosis. Polarization and fouling, membrane module design. Lectures and laboratory.

Goals and Objectives	The students will be introduced to the basic principles of membrane science and technology. The course will cover all basic knowledge of membrane transport, materials (polymeric, inorganic, hybrids), membrane structures and their formation processes, membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation and pervaporation) anad some design principles. The students will also gain some knowledge on practical aspects of membrane science, including some practical demonstrations on membrane formation (hollow fiber spinning) and gas- and liquid permeation testing in the Advanced Membranes and Porous Materials Center, and a visit to the KAUST reverse osmosis and waste water treatment plant.
Required Knowledge	The course is designed for students with various educational backgrounds (chemical engineering, chemistry, physics, materials science, environmental engineering etc.). Some basic knowledge in transport phenomena, separation science, thermodynamics, physics and chemistry is advantageous. However, each lecture will provide enough background information for the novice in the field to follow the more advanced course material.
Reference Texts	**RECOMMENDED TEXTBOOK:** R.W. Baker, *Membrane Technology and Applications*, Wiley. **REFERENCES:** Books: 1. M. Mulder, *Basic Principles of Membrane Technology*, Kluver Academic Publishers. 2. Y. Yampolskii, I. Pinnau, B.D. Freeman, *Materials Science of Membranes for Gas and Vapor Separation*, Wiley. 3. N.N. Li, A.G. Fane, W.S. Ho, T. Matsuura, *Advanced Membrane Technology and Applications*, Wiley. 4. W.S. Ho, K.K. Sirkar, *Membrane Handbook*, Kluver Academic Publishers. 5. K. Scott, *Handbook of Industrial Membranes*, Elsevier. Journals: 1. Journal of Membrane Science (best source for membrane-related information – covers all aspects of membrane science) 2. Science 3. Nature and related journals 4. Advanced Materials 5. Angewandte Chemie – International Edition 6. Macromolecules 7. Journal of Applied Polymer Science 8. Desalination 9. Water Research 10. Polymer Chemistry 11. Environmental Science and Technology 12. Microporous and Mesoporous Materials 13. Journal of the American Chemical Society 14. Langmuir 15. Journal of Materials Chemistry A
Method of evaluation	**60.00**% - Course Project(s) **40.00**% - Midterm exam
Nature of the assignments	The students will be given mandatory weekly reading assignments. The reading assignments will provide additional information for the students in parallel to the course lecture material that will be posted weekly on the blackboard. The students will be assigned to a membrane-related course project that will include an oral presentation and a written report at the end of the semester; the course project will account for 60% of the course grade.
Course Policies	The students are expected to attend all course lectures. If a student is absent, he/she will be required to submit a reason to the instructor per e-mail. In accordance with the University policy and professional standards, the highest levels of academic integrity are expected in this class. The code of student conduct is strictly enforced. Academic dishonesty will result in reductions in grades and/or expulsions from this class and/or the University.
Additional Information	

Tentative Course Schedule *(Time, topic/emphasis & resources)*		
Week	**Lectures**	**Topic**
1	Sun 01/28/2018	Introduction to membrane science
1	Wed 01/31/2018	Introduction to membrane science
2	Sun 02/04/2018	Principles of transport in membranes
2	Wed 02/07/2018	Principles of transport in membranes
3	Sun 02/11/2018	Materials science of membranes
3	Wed 02/14/2018	Materials science of membranes
4	Sun 02/18/2018	Membrane formation principles
4	Wed 02/21/2018	Membrane formation principles
5	Sun 02/25/2018	Membrane characterization techniques (water permeability; gas permeation, diffusion and sorption techniques; electron microscopy)
5	Wed 02/28/2018	Membrane characterization techniques (water permeability; gas permeation, diffusion and sorption techniques; electron microscopy)
6	Sun 03/04/2018	Membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation, pervaporation)
6	Wed 03/07/2018	Membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation, pervaporation)
7	Sun 03/11/2018	Membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation, pervaporation)
7	Wed 03/14/2018	Membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation, pervaporation)
8	Sun 03/18/2018	Modules and System Designs. First discussion on course project
8	Wed 03/21/2018	Lab demonstrations
9	Sun 03/25/2018	Midterm exam preparation
9	Wed 03/28/2018	Midterm exam
10	Sun 04/01/2018	Spring break
10	Wed 04/04/2018	Spring break
11	Sun 04/08/2018	Discusion of midterm exam; preparation for KAUST reverse osmosis plant field trip
11	Wed 04/11/2018	Polymer membranes
12	Sun 04/15/2018	Polymer membranes
12	Wed 04/18/2018	Reverse osmosis and wastewater membrane plants field trip
13	Sun 04/22/2018	Mitigation of fouling in membranes
13	Wed 04/25/2018	Inorganic membranes
14	Sun 04/29/2018	Mixed matrix membranes
14	Wed 05/02/2018	Special student topic - careers in membrane science and technology
15	Sun 05/06/2018	Project evaluations (presentations)
15	Wed 05/09/2018	Project evaluations (presentations)
16	Sun 05/13/2018	Project evaluations (presentations)
16	Wed 05/16/2018	Project evaluations (presentations)
17	Sun 05/20/2018	Final reports due
17	Wed 05/23/2018	Final grade evaluation

Note

The instructor reserves the right to make changes to this syllabus as necessary.