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

<table>
<thead>
<tr>
<th>Division</th>
<th>Physical Science and Engineering Division</th>
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<tbody>
<tr>
<td>Course Number</td>
<td>CE 336</td>
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<tr>
<td>Course Title</td>
<td>Membrane Sc. and Membr. Separation Proc.</td>
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<tr>
<td>Academic Semester</td>
<td>Spring</td>
</tr>
<tr>
<td>Academic Year</td>
<td>2019/2020</td>
</tr>
<tr>
<td>Semester Start Date</td>
<td>01/26/2020</td>
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<tr>
<td>Semester End Date</td>
<td>05/13/2020</td>
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<tr>
<td>Class Schedule (Days &amp; Time)</td>
<td>02:30 PM - 04:00 PM</td>
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### Instructor(s)

<table>
<thead>
<tr>
<th>Name</th>
<th>Email</th>
<th>Phone</th>
<th>Office Location</th>
<th>Office Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ingo Pinnau</td>
<td><a href="mailto:ingo.pinnau@kaust.edu.sa">ingo.pinnau@kaust.edu.sa</a></td>
<td>+966128082406</td>
<td>By appointment only. Office location: Building 4 (Al-Jazri), room 4219 Please send a request at least two days prior to the office appointment per e-mail (<a href="mailto:ingo.pinnau@kaust.edu.sa">ingo.pinnau@kaust.edu.sa</a>) or after each course lecture.</td>
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### Teaching Assistant(s)

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<th>Name</th>
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<td>N/A</td>
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### Course Information

**Comprehensive Course Description**
The course will cover all basic principles of membrane 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**
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) and 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


**REFERENCES:**

**Books:**


**Journals:**

2. *Science*
3. *Nature and related journals*
4. *Advanced Materials*
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

<table>
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<tr>
<th>Percentage</th>
<th>Description</th>
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<tbody>
<tr>
<td>60.00%</td>
<td>Course Project(s)</td>
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<tr>
<td>40.00%</td>
<td>Midterm exam</td>
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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 given a written (closed book) exam which counts for 40% of the final grade. 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
<table>
<thead>
<tr>
<th>Week</th>
<th>Lectures</th>
<th>Topic</th>
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| 1    | Sun 01/26/2020| Semester starts  
Introduction                                                          |
| 1    | Wed 01/29/2020| Introduction to membrane science                                       |
| 2    | Sun 02/02/2020| Introduction to membrane science                                       |
| 2    | Wed 02/05/2020| Principles of transport in membranes                                   |
| 3    | Sun 02/09/2020| Principles of transport in membranes                                   |
| 3    | Wed 02/12/2020| Materials science of membranes                                         |
| 4    | Sun 02/16/2020| Materials science of membranes                                         |
| 4    | Wed 02/19/2020| Membrane formation principles (including lab)                          |
| 5    | Sun 02/23/2020| Membrane formation principles (including lab)                          |
| 5    | Wed 02/26/2020| Membrane characterization techniques (water permeability; gas permeation; diffusion and sorption techniques; electron microscopy) |
| 6    | Sun 03/01/2020| Membrane characterization techniques (water permeability; gas permeation; diffusion and sorption techniques; electron microscopy) |
| 6    | Wed 03/04/2020| Membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation, pervaporation) |
| 7    | Sun 03/08/2020| Membrane processes (microfiltration, ultrafiltration, nanofiltration, reverse osmosis, gas separation, pervaporation) |
| 7    | Wed 03/11/2020| First discussion on course project                                     |
| 8    | Sun 03/15/2020| Simple proces designs                                                  |
| 8    | Wed 03/18/2020| Midterm exam                                                           |
| 9    | Sun 03/22/2020| Spring break                                                           |
| 9    | Wed 03/25/2020| Spring break                                                           |
| 10   | Sun 03/29/2020| Discussion of midterm exam; preparation for KAUST reverse osmosis plant field trip |
| 10   | Wed 04/01/2020| Polymer membranes – special topics                                     |
| 11   | Sun 04/05/2020| Inorganic and hybrid membranes (zeolites, carbon molecular sieves, metal-organic frameworks) |
| 11   | Wed 04/08/2020| Inorganic and hybrid membranes (zeolites, carbon molecular sieves, metal-organic frameworks) |
| 12   | Sun 04/12/2020| Mixed-matrix membranes                                                 |
| 12   | Wed 04/15/2020| Membrane fouling                                                       |
| 13   | Sun 04/19/2020| Reverse osmosis and water treatment trip                               |
| 13   | Wed 04/22/2020| Project evaluations (students oral presentations)                     |
| 14   | Sun 04/26/2020| Project evaluations (students oral presentations)                     |
| 14   | Wed 04/29/2020| Project evaluations (students oral presentations)                     |
| 15   | Sun 05/03/2020| Project evaluations (students oral presentations)                     |
| 15   | Wed 05/06/2020| Final project reports due                                              |
| 16   | Sun 05/10/2020| Final exam week                                                        |
| 16   | Wed 05/13/2020| Semester ends - final grade evaluation                                |

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