CHE 302
Fall 2012

Course Title: Heat and Mass Transfer Operations

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Description: Fundamentals of heat and mass transfer. Heat and mass transfer design equations as applied to selected unit operations. Mass transfer in stage-wise and continuous contacting equipment. Unsteady state operations in mass transfer equipment. Prerequisite: CHE 301. (3-0-3).

Lecture hours: TR 11:25 AM to 12:40 PM

Course Goals:
1- To gain an understanding of the principles of mass and heat transfer phenomena.
2- To apply principles of mass and heat transfer to analysis and design of unit operation systems.


Evaluation: Based on 1 test, midterm exam, and final exam, homework, and computer project.

<table>
<thead>
<tr>
<th>EFFORT</th>
<th>POINTS</th>
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<tbody>
<tr>
<td>Midterm</td>
<td>25 points</td>
</tr>
<tr>
<td>Tests (1)</td>
<td>25 each</td>
</tr>
<tr>
<td>Final</td>
<td>30</td>
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<tr>
<td>Homework (10-12 sets)</td>
<td>10</td>
</tr>
<tr>
<td>Quizzes (5)</td>
<td>5</td>
</tr>
<tr>
<td>Computer Projects (1)</td>
<td>5</td>
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Total 100

The better of the grades of the Test and Midterm will be used with a 50% wt. in class grade calculations.

**Grade:**

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
<th>Points</th>
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<tbody>
<tr>
<td>A</td>
<td>90% of points</td>
<td>90 - 100</td>
</tr>
<tr>
<td>B</td>
<td>80%</td>
<td>80 - 90</td>
</tr>
<tr>
<td>C</td>
<td>70%</td>
<td>70 - 80</td>
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<tr>
<td>D</td>
<td>60%</td>
<td>60 - 70</td>
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If class average falls below 60% on any test/exam, standard curving will be done.

**Homework Policy:**

* by 5:15 PM on due date - full credit
* One day after due date - 70% off
* More than one day late - no credit

**Exams:**

All exams and tests will be open book/notes. Final exam will not be cumulative.

NO RETAKES OF THE TESTS/ FINAL ALLOWED.

MAKE-UP TEST/ EXAM ALLOWED FOR PERSONAL EMERGENCIES ONLY

**Quizzes:**

Unannounced, both open and closed book. No make-up for missed quizzes.

**Course Outline**

1- Basic mechanisms of heat transfer
2- Heat Conduction
   Fourier’s law
   Thermal conductivity
   Steady state energy balance with conduction only
   a- rectangular coordinate system
   b- Cylindrical coordinate system
   c- Spherical coordinate system
   Conduction through materials in series and parallel
   Contact resistance
   Conduction with inside heat generation
3- Forced convection heat transfer
   Heat transfer coefficient
   Correlations for heat transfer coefficient
   Overall heat transfer coefficient and log mean temperature difference
4- Natural convection heat transfer
   Heat transfer coefficient correlations
5- Boiling and condensation
6- Heat Exchangers
   Configurations
   a- parallel
b- countercurrent
c- cross-flow
d- multi-pass

Fouling factors and typical overall U values
Finned surface heat exchangers

7- Basic mechanisms of mass transfer, analogy and differences with heat transfer
8- Molecular Diffusion
   Fick’s law
   Molecular diffusion plus convection- special cases
   Diffusion in different geometries in one dimension
   Steady state multidimensional molecular diffusion
   Molecular diffusivity –Experimental methods and prediction
9- Convective mass transfer
10- Convective mass transfer coefficient
    Dimensionless groups and correlations
11- General balance equation for mass transfer
12- Application to reactive systems
13- Knudsen diffusion
14- Separation processes
    Stagewise and Continuous contactors
    Absorption in a trayed column-Kremeser equations
    Absorption in a packed column
    Humidification in packed columns-cooling tower process calculations and design
    Membrane separation of gases and liquids
15- Term project

Student Learning Objectives (SLOs):
Upon completion of this course, students will be able to:
1. Determine material balance in systems involving molecular diffusion.
2. Apply Fick’s law to dilute and concentrated systems under steady state conditions for various geometry.
3. Predict binary diffusivity in different phases from the available theories and correlations.
4. Calculate interfacial equilibrium concentrations for transport of material from one phase to another.
5. Derive material and energy balance equations for packed bed humidification and drying processes.
6. Use the analytical methods of Kremser to determine number of equilibrium stages in dilute separation processes for binary systems.
7. Design membrane systems for separation of gases, reverse osmosis, and ultra-filtration.
8. Understand basic concepts in heat transfer such as energy, heat, thermal conductivity and temperature.
10. Be able to calculate heat transfer coefficients for pipe flow and understand the physical significance of the Nusselt number.
11. Be able to apply integral thermal energy balance in conjunction with empirical correlations for heat transfer coefficients in the design and analysis of heat exchangers.
12. Be able to formulate and solve linear ordinary differential equations that are relevant to unit operations involving heat transfer.

Course Relationship to CHE program Educational Objectives:
This intermediate level course contributes to the CHE program objectives & outcomes as follows:
Outcome II: Students learn fundamentals of mass and heat transfer. This outcome is supported by SLOs 1 to 4 and 8-10.
Outcome III: Students develop engineering judgment and gain experience related to design of unit operation processes. This outcome is supported by SLOs 5 thru 7 and 11.
Outcome IV: Students use spreadsheets and other engineering software for data analysis and presentation. This outcome is supported by SLO 7.
Outcome IX: The entire ChE curriculum is designed to instill in the students a yearning for the pursuit of “Life Long Learning”, and the skills necessary for it. Each course achieves this goal by various means. The assessment plan for this outcome is currently under development, data are continually being collected to
assess the whole range of methodologies that are used in this regard. All data collected will be used by the outcome XI assessment committee (in Year 3) to formulate future metrics.