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In Class Experience Using the Web and a New Text for Teaching Undergraduate Mass and Heat Transfer

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In this presentation we describe a novel method for teaching undergraduate mass and heat transfer. The material is based on a new text (Mass and Heat Transfer, Cambridge Univ. Press, 2008) developed at the University of Delaware over the past 8 years. The text is organized into two parts and is a significant departure from the traditional courses in heat and mass transfer. The course and text is enriched by an interactive web site (www.mht.che.udel.edu) that can be used by students individually as well as by the instructor in class.

A competitive game on the web site requiring reactor model development and economic analysis allows us to effectively review reactor design. Student activities on the web site build upon this to develop interactive derivations of the key model equations. To illustrate the technically feasible design of mass contactors and heat exchangers, interactive role playing exercises are included.

Part I of the text we use in class analyzes and models laboratory, pilot, and commercial scale equipment for reaction, heat exchange and mass contact. The equipment is classified by the simplified fluid motions occurring in reactors, heat exchangers and mass contactors: mixed-mixed and mixed-plug tank-type equipment and plug flow cocurrent and countercurrent tubular equipment (Table 1). Part I clearly shows the critical role of experiment essential for evaluating parameters in the correlations for heat transfer and mass transfer presented in Part II. The model equations from Part I are applied to interactive technically feasible analysis and design on the web site.

Part II first examines molecular-level conduction and diffusion and relates this to the equipment-scale model equations. We next relate physical properties and detailed fluid motions to the equipment-scale analysis in Part I. State-of-the-art methods for estimation of fluid-fluid interfacial areas critical to the analysis and design of mass contactors are developed as a separate chapter. Finally detailed technically feasible designs for a heat exchanger, a countercurrent mass contactor, a staged liquid-liquid extraction unit and a fermentor are presented.

We teach the material in this manner so students first study equipment, which is of importance for planning and execution of experiments and for processing of material at the commercial scale. An additional benefit of this organization is that Part I and selected correlations from Part II can stand alone and can replace the traditional courses in fluid mechanics and heat and mass transfer. This allows new material to be introduced into a chemical engineering curriculum, for

example, critical courses in the biological engineering and sciences. It could also serve as a stand alone course for non-chemical engineers to learn basics of transport phenomena and their application.

REACTORS SINGLE PHASE	REACTORS TWO PHASE	HEAT EXCHANGERS	MASS CONTACTORS
Single Control Volume	Two Control Volumes	Two Control Volumes	Two Control Volumes
Tank Type ***Mixed*** • **Batch** • **Semi- Batch** • **Continuous**	**Tank Type** *Mixed –Mixed* • Batch • Semi-Batch • Continuous *Mixed -Plug* • Semi-Batch • Continuous	**Tank Type** *Mixed –Mixed* • Batch • Semi-Batch • Continuous *Mixed -Plug* • Semi-Batch • Continuous	**Tank Type** *Mixed –Mixed* • Batch • Semi-batch • Continuous *Mixed -Plug* • Semi-Batch • Continuous
Tubular ***Plug Flow***	**Tubular** *Plug Flow* *Co Current*	**Tubular** *Plug Flow* *Co Current* *Counter Current*	**Tubular** *Plug Flow* *Co Current* *Counter Current*

TABLE 1
(reproduced from "Mass and Heat Transfer: Analysis of Mass Contactors and Heat Exchangers." Cambridge Univ. Press, 2008)

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