1. **Course number and name - CHBE 4200/4210**
   – Unit Operations/Bioprocess Unit Operations Laboratory *(required)*

2. **Credits and contact hours** - 3 credit hours, 2 lecture hours and 3 lab hours (2-0-3-3)

3. **Instructor's or course coordinator's name -** Dr. Yonathan Thio and
   Jacqueline Mohalley-Snedeker

4. **Textbook, title, author, and year**
   None (All materials are available in class or on our online course management system, Canvas). Students also use reference texts from previous classes or the library.

5. **Specific course information**
   a. **Catalog Description –** This course illustrates engineering/scientific principles and physical models important to the data collection/interpretation of process important to the practice of chemical engineering.
   b. **Prerequisites or co-requisites** – CHBE 3210 Transport Phenomena II (grade "C" or better); CHBE 3225 Separations Processes (grade "C" or better); CHBE 4300 Kinetics and Reactor Design (pre-requisite with concurrency).
   c. **Required, elective, or selected elective course** (as per Table 5-1) – Required

6. **Specific goals for the course**
   a. **Specific outcomes of instruction**:
      By the end of this course, a student should be able to:
      1) Work effectively in 3- or 4-person teams to cooperatively carry out a project involving problem identification, data gathering and analysis, and written and oral communication.
      2) Determine an experimental objective, understand the theory behind the experiment, and operate the relevant equipment safely.
      3) Analyze experimental data using standard statistical methods to establish quantitative results.
      4) Write effective technical reports for the experiments.
      5) Serve as team leader for two experiments and make two oral presentations.
   b. **Connection with Student Outcomes**

CHBE 4200/4210							
	Student Outcomes						
Course Outcomes	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Course Outcome 1			**X**	**X**	**X**	**X**	**X**
Course Outcome 2	**X**		**X**	**X**	**X**	**X**	**X**
Course Outcome 3	**X**			**X**		**X**	
Course Outcome 4			**X**	**X**			
Course Outcome 5	**X**		**X**	**X**	**X**	**X**	**X**

Student Outcomes

(1) an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics

(2) an ability to apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors

(3) an ability to communicate effectively with a range of audiences

(4) an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts

(5) an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives

(6) an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

(7) an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

7. **Brief list of topics to be covered**
   a. Continuous Stirred Tank Reactor
      1) Unsteady and steady-state operation
      2) Reversible/irreversible reaction kinetics
      3) Fundamental model
   b. Fluidized Bed
      1) Ergun equation
      2) Minimum fluidization velocity and pressure drop
      3) Gas and liquid fluidization
   c. Agitated Aerobic Fermentation
      1) Gas-liquid mass transfer coefficient
      2) Yeast catalyzed fermentation
      3) Gassed power consumption
      4) Stirred reactor scale-up
   d. Heat Exchanger
      1) Shell and tube and plate types
      2) Co-current and counter-current flow
      3) Overall heat transfer coefficient
      4) Fouling coefficient
   e. Fractional Distillation
      1) McCabe-Thiele method
      2) Overall column efficiency and Murphree plate efficiency
      3) Optimum feed plate location
      4) Reflux ratio
   f. Isomerization in a Packed Bed Reactor
      1) Glucose-fructose isomerization
      2) Michaelis-Menten kinetics
      3) External mass transfer and pore diffusion
      4) Rate limiting step
      5) Thiele Modulus and Effectiveness Factor
      6) Packed bed mass and volumetric productivity
   g. Membrane Separation
      1) O_2/N_2 separation
      2) Retentate and permeate purity

   3) Permeance and selectivity
   4) Flow configuration

h. Protein Separation from Fermentation Broth
   1) Biomass and protein quantification
   2) Centrifugation, sonication, tangential flow filtration, and homogenization
   3) Bradford assay
   4) Lambert-Beer's law for absorbance

i. Enzyme Membrane Reactor
   1) Biocatalytic reaction
   2) Membrane filtration
   3) Continuous stirred tank reactor
   4) Biot's law for optical activity
   5) Enzyme leakage rate

j. Transdermal Drug Delivery
   1) Model compounds through mouse skin
   2) Biological tissue sample preparation
   3) Diffusion and permeability
   4) Lag time
   5) Statistical significance of differences