

1. **Course number and name - CHBE 3200 – Transport Phenomena I (required)**

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

3. **Instructor's or course coordinator's name - Dr. Victor Breedveld (SU23)**

4. **Textbook, title, author, and year**

Fundamentals of Momentum, Heat and Mass Transfer, 7th edition, J.R. Welty, G.L. Rorrer and D.G. Foster, John Wiley & Sons Inc. (2018) (6<sup>th</sup> edition also suitable)

5. **Specific course information**

- a. **Catalog Description** - The basic principles of fluid mechanics and heat transfer are introduced and the analysis and design of equipment using these principles is practiced.
- b. **Prerequisites or co-requisites** – MATH 2551 Multivariable Calculus (grade “C” or better); MATH 2552 Differential Equations (grade “C” or better); PHYS 2211 Introductory Physics I (grade “C” or better); CHBE 2130 Chemical Engineering Thermodynamic I (grade “C” or better); CHBE 2120 Numerical Methods in Chemical Engineering (grade “C” or better).
- 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) Design/simulate the operation of process piping systems (estimate frictional losses, size pipes, size pumps, etc.) for the specific flow of liquids and gases.
- 2) Design/simulate the operation of packed beds, fluidized beds, and filters for specified fluid flow rates.
- 3) Design flow models and interpret experimental data using dimensional analysis.
- 4) Apply the macroscopic balances of mass, momentum, and energy, as well as the differential continuity equation and the equations of motion to simple systems using both Cartesian and polar coordinates.
- 5) Apply the Fourier law of heat conduction to homogeneous and heterogeneous objects of various shapes.
- 6) Estimate transient and steady state heat transfer rates from/to object such as tanks, pipes, buildings, etc.
- 7) Apply principles of radiative heat transfer.

**b. Connection with Student Outcomes**

CHBE 3200							
	Student Outcomes						
Course Outcomes	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Course Outcome 1	X	X					
Course Outcome 2	X					X	
Course Outcome 3	X					X	
Course Outcome 4	X						
Course Outcome 5	X						
Course Outcome 6	X	X					
Course Outcome 7	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. Fluid Statics
  - 1) Concept of fluid stresses, pressure
  - 2) Buoyancy
- b. Macroscopic Balance Equations of Fluid Motion
  - 1) Macroscopic mass balance
  - 2) Macroscopic momentum balance
  - 2) Macroscopic energy balance, Bernoulli's equation
- c. Shear Stress in Laminar Flow
  - 1) Shell momentum balance, velocity profile
  - 2) Non-Newtonian fluids, pipe flow
- d. Differential Balance Equations
  - 1) Differential mass balance: continuity equation
  - 2) Shell momentum balance, non-Newtonian Fluids
  - 3) Differential momentum balance, Navier-Stokes equations
  - 4) Analysis of flow profiles
- e. Dimensional Analysis
  - 1) Similarity
  - 2) Buckingham Methods, Model Analysis
- f. Theory and Applications of Viscous Flow
  - 1) Boundary layer theory, form drag
  - 2) Mechanical energy balance, frictional losses

- 3) Piping networks
- 4) Flow in packed and fluidized beds
- 5) Filtration
- 6) Pumps, developed head, lift, cavitation
- g. Steady-state Heat Transfer
  - 1) Fourier's law of heat conduction, Newton's law of cooling (convection)
  - 2) Differential energy balance, steady-state limit
  - 3) One-dimensional heat conduction, heat transfer from extended surfaces
  - 4) Multi-dimensional heat transfer
- h. Transient Heat Transfer
  - 1) Heat transfer in the regimes of high, low and intermediate Biot number
  - 2) Boundary layer approach to heat conduction
- i. Radiation Heat Transfer
  - 1) Black body radiation, Planck's law, Stefan-Boltzmann law
  - 2) Kirchhoff's law, radiation heat exchange between real bodies