1. **Course number and name - CHBE 4411 – Process Dynamics and Control** ***(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. Martha Grover

4. **Textbook, title, author, and year**
   Seborg, Edgar, Mellichamp, and Doyle, "Process Dynamics and Control," 4th edition, Wiley, 2016.

5. **Specific course information**
   a. **Catalog Description –** Dynamics of chemical processes and their control. Techniques of conventional process control as well as digital control.
   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) Understand and discuss the importance of process control in process operation and the role of process control engineers.
      2) Understand and design the modern hardware and instrumentation needed to implement process control.
      3) Develop mathematical models of chemical and biological processes by writing unsteady- state mass and energy balances.
      4) Recognize and fit various simple empirical models that are used for designing controllers.
      5) Analyze linear dynamical systems using matrix algebra and Laplace transforms.
      6) Design and tune feedback controllers.
      7) Analyze stability and performance of feedback loops using Laplace and frequency domain techniques.
   b. **Connection with Student Outcomes**

CHBE 4411							
	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**						
Course Outcome 4	**X**					**X**	
Course Outcome 5	**X**						
Course Outcome 6	**X**	**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. Introduction to process dynamics and process control
b. Control Loop Hardware
   1) Sensors, transmitters, and control valves
   2) Distributed control systems
   3) Smart instrumentation and field bus
c. Dynamic Modeling and Simulation
   1) Lumped and distributed parameter systems
   2) Numerical solution of nonlinear AEs and ODEs.
d. Laplace Transform Based Analysis
   1) Linearization of nonlinear ODEs
   2) Laplace transform and transfer function
e. Models for Control
   1) 1st order, 2nd order, and higher order systems
   2) Generalization ("Making friends with transfer functions)
f. Frequency Response Analysis
   1) Frequency response and Bode diagram
   2) Sketching Bode diagram for general transfer functions
g. Analysis of feedback systems
   1) Laplace domain analysis (characteristic equation)
   2) Frequency domain analysis (Bode stability criterion)
h. PID Control
   1) Reaction curve based PID controller tuning
   2) Continuous cycling based PID controller tuning
i. Control Strategies
   1) Feedforward control, cascade control, and ratio control
   2) Anti-windup and bumpless transfer
j. Multivariable Control
   1)Interactions in multi-loop control
   2) Relative Gain Array (RGA), interaction measure, and loop pairing
   3) Control strategies and optimization based Model Predictive Control
k. Statistical Process Control - Complementary role of SPC with respect to APC