ABET-Course Syllabus

1. **Course number and name:** (0905482) Process Dynamics and Control
2. **Class schedule:** 3 Credits Hours
   a. **Time and place**:
   b. **Office hours**:
3. **Instructor:** Dr. Mohammad Al-Shannag
4. **Text book:** Seborg D.E., T.F. Edgar, D.A. Mellichamp, and Doyle F.J., *Process Dynamics and Control*, 3rd Ed., John Wiley & Sons Inc., New York, NY (2011).

   Other interesting references:

   Books
   - Stephanopoulos, G., *Chemical Process Control*, Prentice-Hall Inc., Englewood Cliff, New Jersey, (1984).
   - Smith C.A. and Coripio A. B., *Principles and Practice of Automatic Process Control*, 3rd Ed., John Wiley & Sons Inc., New York, NY (2006).

   Journals:
   - Control Engineering Practice:
     http://www.journals.elsevier.com/control-engineering-practice
   - Chemical Engineering Science:
     http://www.journals.elsevier.com/chemical-engineering-science

5. **Course information:**
   a. **Catalog description**: Introduction to control systems. Modeling of dynamic behavior of chemical processes. Transfer functions. Dynamic behavior of first and second order systems. Analysis and design of control systems: types of controllers, closed loop response, stability, design of feedback controllers. Analysis of frequency response of linear systems. Design using frequency response techniques.
   b. **Pre or co-requisite**: 0965442 Heat and Mass Transfer Operations
   c. **Course classification**: Mandatory course in the B.Sc. program.

6. **Specific goals of the course:**

This course is devoted primarily to the basic principles and practical applications of process dynamics and control. Upon the successful completion of the course, the student will be able to:	O 1	O 2	O 3	O 4	O 5	O 6	O 7
Apply chemical engineering concepts built in previous courses to develop dynamic models of processes.							
Decide the suitable control strategy to maintain the chemical process at the desired conditions.							
Describe process dynamics and control terminology such as controlled/manipulated/disturbance variables, setpoint, offset, servo/regulator problems, controller tuning, actuators overshoot, decay ratio, delay time, Span, zero, pneumatic signals, …etc.							
Solve and analyze 1st-order and 2nd-order dynamic models of some interacting/nointeracting processes.							
Transform models from their actual variable forms to the							

corresponding deviated variable forms.							
Linearize single and multi-variables nonlinear models using Taylor series expansion.							
Solve linear/linearized models using Laplace Transforms							
Identify standard instrumentation signals.							
Distinguish between reverse and direct action controllers.							
Formulate transfer functions for sensor-transmitters, noise filters, actuators, and controllers.							
Estimate the gain of converters, transmitters, and control valves.							
Select air-to-open air-to-close actuators based on safety considerations.							
Design closed-loop feedback control system with proportional (P), proportional integral (PI), proportional integral derivative (PID) controllers.							
Develop transfer functions of closed-loop feedback control system of servo or regulatory modes.							
Test the dynamic response, performance, and stability of the closed-loop feedback control system.							
Tune controller parameters using Cohen-Coon or Ziegler-Nichols methods in order to achieve stable response and convincing performance.							
Perform frequency response representation of a system dynamics to design a feedback controller and to analyze closed-loop system.							
Use some computer softwares such as Simulink in Matlab to design and analyze control systems.							

7. **Course topics:** Course topics will be covered through around 42 (50 minutes) classes according to the following distribution:

Topic	# of classes
Introduction to process control: industrial perspectives; what is process control? Specific objectives of control; justification of process control, process control terminology, control strategies: manual and automatic control (feedback, feedforward, cascade); process control instrumentation; control system development; performance of process control.	5
Mathematical modeling of chemical processes : basic concepts and definitions; model (theoretical , Empirical semi-empirical; steady-state/dynamic models; linear/nonlinear models; systematic approach for developing dynamic models; degree of freedom analysis; model solution, models of representative processes	6
Laplace Transforms: mathematical definition of Laplace transform (LT) and its inverse; LT of functions common in process control; properties of LT: differentiation, integration, initial and final value theorems; LT inverse via partial fraction expansion; useful LT features in process control; solving ordinary differential equations by LT.	3
Transfer function models: definition of transfer function (TF); general procedure for developing TF; properties of TF model: TF order, physical realizability, steady	5

state gain additive property, multiplicative property.	
Dynamic behavior of first- order and second-order processes: dynamic responses for the following standard types of input changes: step change, ramp, impulse, rectangular pulse, and Sinusoidal; response of integrating and interacting/nointeracting processes, characteristic of overdapmed, underdamped and critically damped responses; Bode diagram analysis effect of pole/zero location.	6
Process controllers: standard block diagram of feedback controller; Servo/regulatory control; span and zero; On-Off controller; properties of feedback controller: proportional, integral, and derivative; reverse/direct control action; key characteristics of commercial PID controllers.	3
Sensors, Transmitters, Filters, and Actuators: definitions; transfer functions and gains of these control elements; various kind these elements; standard instrumentation signals; selection of air-to-open/air-to-close actuators.	5
Dynamic Behavior and Stability of Closed-Loop Control System: block diagram representation; closed-loop transfer functions; Mason's Rule; closed-loop response for set point/ disturbance changes; response stability: general stability criterion, Routh-Hurwitz criterion, direct substitution criterion; root locus diagram; effect of dead time, on the closed-loop performance; controller tuning using Cohen-Coon and Ziegler-Nichols methods.	6
Frequency response Analysis: definition; benefits of frequency analysis; how to get frequency response; Bode plot; Nyquist diagram.	3

8. Policies and procedures:

Attendance. Students are expected to attend each class session and they are responsible for all material, announcements, and schedule changes discussed in class. University policy states that teachers must keep a record of attendance throughout the semester and may impose academic penalties commensurate with the importance of the work missed because of unexcused absences.

Lateness. Coming late to class is disruptive and may be treated as an unexcused absence.

Homework. There will be homework assignments in this course. Students are encouraged to discuss assignments, but *every student must turn in his/her own written solutions in his/her own words*. However, students must submit homework individually. Each assignment should be presented in a neat organized manner, with a cover page including the course title, student's name, homework number, and due date. It is better to write problem statement before its solution; do not turn in solutions only. Late assignments will not be accepted. *Problem set solutions will not be posted*; it is your responsibility to make sure you find out how to solve the problems by, for example, discussing them with me during classes or office hours. All cases of academic dishonesty will be handled in accordance with university policies and regulations.

Quizzes. There will be a number of announced/unannounced quizzes during the semester. Students are expected to be ready to take a quiz any time they have a class. There will be no make-up quizzes.

Teamwork. Some projects may be performed by groups of no more than three students. The topics will be decided after the midterm exam. One final project report will be submitted by each group.

Computer skills. You are encouraged to use computer softwares such as excel, Matlab, or Polymath to perform the required computations and to represent your findings in graphs or tables.

Grading Policy. A weighted average grade will be calculated as follows:

- Midterm examination:	30%
- Quizzes, assignments, and projects:	30%
- Final examination	40%

9. Contribution of Course to Meeting the Professional Component:

This course contributes to building the fundamental concepts in process dynamic and control and its applications in Chemical Engineering.

10. Relationship to Program Outcomes (%):

O1	O2	O3	O4	O5	O6	O7
x	x			x		

11. Relationship to Chemical Engineering Program Objectives

PEO1	PEO2	PEO3	PEO 4
√	√	√	√

Prepared by: Dr. Mohammad Al-Shannag
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