Course Unit	Process Dynamics and Control	Field of study	Chemical Process Simulation, Control and Optimization
Master in	Chemical Engineering	School	School of Technology and Management
Academic Year	2019/2020	Year of study	1
Level	2-1	ECTS credits	6.0
Type	Semestral	Semester	1
Code	6362-354-1102-00-19		

Workload (hours)	Contact hours	T	TP	PL	TC	S	E	OT	O
162		30	-	30	-	-	-	-	-

T - Lectures; TP - Lectures and problem-solving; PL - Problem-solving, project or laboratory; TC - Fieldwork; S - Seminar; E - Placement; OT - Tutorial; O - Other

Name(s) of lecturer(s)	Rolando Carlos Pereira Simões Dias

Learning outcomes and competences

At the end of the course unit the learner is expected to be able to:
1. Recognize the motivations to study dynamics and control of chemical process.
2. Perform the linearization of systems with multiple variables.
3. Use conservation laws to obtain transfer functions and apply this concept to analyze open loop dynamic systems.
4. Quantify the dynamic behavior of first order systems and identify typical examples associated to chemical processes.
5. Quantify the dynamic behavior of second order and higher order systems and identify typical examples associated to chemical processes.
6. Quantify the dynamic behavior of feedback controlled systems. Identify typical chemical processes controlled by feedback.
7. Analyze and quantify the stability of feedback controlled systems.
8. Apply MATLAB to real domain analysis of system dynamics (numerical solution of IVP). Use MATLAB and SIMULINK to analyze the open loop dynamics and the closed loop control of dynamic systems.

Prerequisites

Before the course unit the learner is expected to be able to:
1. Know and quantify heat, mass and momentum transfer phenomena.
2. Establish and solve conservation laws.
3. Know chemical processes.

Course contents

Motivations to perform the control of chemical process. Linearization of dynamic systems and Laplace transforms. Transfer functions. Dynamic behavior of first and second order systems. High order systems. Dynamic behavior and stability of feedback systems.

Course contents (extended version)

1. Motivations to perform the control of chemical process
   - Influence of external disturbances, stability of chemical process, optimization of chemical process.
   - Laws of conservation of momentum, energy and mass.
   - Control of a heated stirred tank, unstable chemical reactor, optimization of a batch reactor.
2. Linearization of dynamic systems and Laplace transforms
   - Linearization of systems with multiple variables.
   - Laplace transforms: properties and applications.
   - Transfer functions: properties and applications.
   - Poles and zeros of transfer functions. Stability.
3. Dynamic behavior of first order systems
   - Disturbances of dynamic systems.
   - Real time models. Transfer function and associated parameters.
   - Dynamic systems with capacity for mass and energy storage.
   - Pure capacitive systems.
   - Characterization of the dynamic response of first order systems. Case studies.
4. Dynamic behavior of second order systems
   - Real time models. Transfer function and associated parameters.
   - Characterization of the dynamic response of second order systems. Damping factor effect.
   - Second order dynamic systems resulting from two first order systems in series.
   - Inherently second order dynamic systems.
   - Case studies.
5. Dynamic behavior of higher-order systems
   - N first-order systems in series.
   - Dynamic systems with dead time.
   - Dynamic systems with inverse response.
6. Dynamic behavior of feedback systems
   - Closed loop dynamics. Control objectives, loads, controlled variables, set-point.
   - Block diagram and algebra of control loops. Quantification of closed loop responses.
   - Servo and regulator problems. Feedback controllers.
   - Analysis of case studies involving feedback control.
7. Stability of feedback systems
   - Stability definition and application to closed loop systems response.
   - Poles of the closed loop transfer function. The characteristic equation.
   - Routh-Hurwitz stability criterion. The method of root-locus.
   - Frequency response analysis. Amplitude ratio. Phase lag. Complex domain analysis.
   - Bode diagrams. Nyquist plots.
   - Bode stability criterion. Tuning of controllers. Gain and phase margins.
   - Ziegler-Nichols tuning technique. Nyquist stability criterion.

Recommended reading

1. Process Dynamics and Control, D. E. Seborg, T. F. Edgar, D. A. Mellichamp, 2ª Ed. , Wiley, 2004
2. Ogata, Modern Control Engineering, Prentice-Hall, 2001
3. Principles and Practice of Automatic Process Control, C. A. Smith, A. Corripio, 3ª Ed. , Wiley, 2006
4. Process Dynamics and Control - Modeling for Control and Prediction, B. Roffel, B. Betlem, Wiley, 2006
5. Elementos de Dinâmica e Controlo de Processos Químicos, Rolando Dias, ESTIG, IPB, 2019

Teaching and learning methods

The unit will be taught using a combination of lectures, self guided learning and practice classes. Students will be provided with a study guide and support material, including e-learning facilities.

Assessment methods

1. Alternative 1 - (Regular, Student Worker) (Final, Supplementary, Special)
   - Practical Work - 20%
   - Intermediate Written Test - 25%
   - Intermediate Written Test - 25%
   - Final Written Exam - 30%
2. Alternative 2 - (Regular, Student Worker) (Special)
   - Final Written Exam - 100%
3. Alternative 3 - (Student Worker) (Final, Supplementary)
   - Final Written Exam - 100%

Language of instruction

English

Electronic validation

Rolando Carlos Pereira Simões Dias	Hélder Teixeira Gomes	Simão Pedro de Almeida Pinho	Paulo Alexandre Vara Alves
10-10-2019	10-10-2019	10-10-2019	13-10-2019