INSTITUTO POLITÉCNICO DE BRAGANÇA

Course Unit	Option I - Process Dynamics and Control	Field of study	Physics
Master in	Renewable Energy and Energetic Efficiency	School	School of Technology and Management
Academic Year	2023/2024	Year of study	1
Level	2-1	ECTS credits	6.0
Type	Semestral	Semester	1
Code	6793-475-1101-01-23		

Workload (hours)	Contact hours	T	TP	PL	TC	S	E	OT	O
162		-	60	-	-	-	-	-	-

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 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 different kinds of processes.
5. Quantify the dynamic behavior of second order and higher order systems and identify typical examples associated to different kinds of processes.
6. Quantify the dynamic behavior of feedback controlled systems. Identify typical 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 mass, heat and momentum transfer processes.

Course contents

Motivations to perform the control of 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 process
   - Influence of external disturbances, stability of chemical process, optimization of process.
   - Laws of conservation of momentum, energy and mass.
   - Control of heated stirred tank, optimization of unstable reactor. Common examples in engineering.
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, F. J. Doyle III, 4th Ed, Wiley, 2016
2. Modern Control Engineering, K Ogata, Pearson, 5 edition, 2010
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, John Wiley & Sons, 2006
5. Elementos de Dinâmica e Controlo de Processos, 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

1. Portuguese
2. English

Electronic validation

Rolando Carlos Pereira Simões Dias	Hélder Teixeira Gomes	Luís Manuel Frolen Ribeiro	José Carlos Rufino Amaro
08-10-2023	25-10-2023	25-10-2023	31-10-2023