Università degli Studi di L'Aquila - Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica

# Course catalogue

*Page compiled on 20/08/2019*

## Programme of Course "Teoria dei Sistemi"

- Code: I0637
- Type of course unit: Compulsory (Laurea in Ingegneria dell'Informazione curriculum Automatica), Compulsory (Laurea in Ingegneria dell'Informazione curriculum Telecomunicazioni), Compulsory (Laurea in Ingegneria dell'Informazione curriculum Elettronica), Compulsory (Laurea in Ingegneria dell'Informazione curriculum Comune), Compulsory (Laurea in Ingegneria dell'Informazione curriculum Informatica)
- Level of course unit: Undergraduate Degrees
- Semester: 1

Number of ects credits: (Laurea in Ingegneria dell'Informazione) 9 (workload 225 hours)

Teachers: Costanzo Manes

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| **1** | **Course objectives** | The goal of this course is to introduce students to the analysis of control systems, which are dynamic systems characterized by input and output variables, and state variables. On successful completion of this module, the students should be able to understand the meaning and the use of dynamic models, to use the models for the computation of the output of systems as a function of the input, to analyze the frequency response of a system, to study the stability property of a system before and after the closure of a control-loop, to analyze the structural properties of reachability and observability of the system state. |
| **2** | **Course content and learning outcomes (dublin descriptors)** | Topics of the module include:<br>• Systems and models: examples of electrical, mechanical, thermic, hydraulic systems; definition of causal systems, of state and of input and output functions. The state-transition function and the output transformation.<br>• State-space models of finite-dimensional linear systems: time-domain analysis; unforced and forced system response; the Dirac impulse. The state-transition matrix; the state and output impulse response matrices. Implicit and explicit representations. Time-invariant systems: solution of a system of linear differential equations. Matrix exponential: definition as a series, computation using the spectral decomposition. Convolution integrals and sums. Discretization of continuous-time systems. Coordinate transformations and similar matrices.<br>• time-domain modal analysis: natural modes in the unforced state response. State trajectories: geometric path and time path. Stability, asymptotic stability and instability of natural modes. Natural modes and forced state and output response. Excitability and observability of modes.<br>• Systems analysis using transforms: Laplace transform and z-transform. The use of convolution, derivation and delay theorems in the systems analysis. The use of transforms in the modal analysis and in the computation of the matrix exponential. The use of transforms in the computation of the forced response. Connections between Laplace, Fourier and z-transforms.<br>• Steady state and transient in the system response: the case of exponential and sinusoidal inputs. Harmonic response and frequency analysis. Graphic representations (amplitude and phase) of transfer functions. Decibel, semilog charts and Bode diagrams. Methods for drawing by hand of Bode diagrams. The polar graph of transfer functions (Nyquist plot).<br>• Stability theory: definition of equilibrium point; simple and asymptotic stability of an equilibrium point. Stability of linear time-invariant systems. The Lyapunov criterion. Positive (negative) definite and semi-definite functions. Quadratic forms. Sylvester criterion. Stability analysis by means of linear approximation: the system Jacobian. Lyapunov equation. Routh criterion. Stability of interconnected systems: Nyquist criterion.<br>• Reachability and observability: indistinguishable and unobservable states; the observability matrix and the observability Gramian. The Cayley-Hamilton theorem. Reachable and controllable states. Invariance of unobservable and reachable subspaces. Structural decompositions and Kalman decomposition of systems. Controller and observer canonical forms of systems. State-space realization of |

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| | | transfer functions.<br><br>On successful completion of this module, the student should :<br>• In this module the students learn what is a control system, what are its main properties and the methods for the system analysis.<br>• At the end of the module the student will be able to apply the learned methodologies to the analysis of dynamic systems in various application fields.<br>• The students will be able to evaluate the properties of stability, transient speed and quality of the frequency response in control systems.<br>• By exploiting mathematical models of systems the students will be able to describe and give interpretations of the dynamic behavior of systems in various application fields.<br>• The tools for systems analysis provided in this module allow the students to adequately start the study of control systems design methodologies and of model identification from experiments. |
| **3** | **Course prerequisites** | The students must know the basic notions of calculus, analytic geometry, matrix theory and vector analysis. |
| **4** | **Teaching methodsand language** | Lectures and exercises. Language: Italian<br>**Language**: Italian<br>**Reference textbooks**<br>• A. Giua, C. Seatzu, ***Analisi dei sistemi dinamici***. Springer Verlag. 2009.<br>• O.M. Grasselli, L. Menini, S. Galeani, ***Sistemi dinamici***. Hoepli. 2007.<br>• A. Ruberti, A. Isidori, ***Teoria dei Sistemi***. Boringhieri . 1979.<br>• A. Ruberti, A. Isidori, ***Teoria della stabilità***. Siderea. 1977. |
| **5** | **Assessment methods** | Written and oral examination. |