Z1-PU7	WYDANIE N1	Strona 1 z 3

(*faculty stamp*)

COURSE DESCRIPTION

1. Course title: MODELLING AND SIMULATION OF INDUSTRIAL SYSTEMS	**2. Course code**
3. Validity of course description: 2016/2017	
4. Level of studies: BSc programme / MSc programme	
5. Mode of studies: intramural studies	
6. Field of study: MACROCOURSE	(FACULTY SYMBOL)
7. Profile of studies: general	
8. Programme: Automatic Control	
9. Semester: 2	
10. Faculty teaching the course: Institute of Automatic Control, Rau1	
11. Course instructor: dr hab. inż. Jacek Czeczot	
12. Course classification: programme courses	
13. Course status: compulsory /elective	
14. Language of instruction: English	

15. Pre-requisite qualifications: Mathematics, Physics, Numerical methods, Process dynamics, Control fundamentals. It is assumed that students have basic skills in dynamical and input-output modelling, they know the modelling in the form of linear and nonlinear state equations for simple dynamical processes, they have ability of linearizing nonlinear dynamical models and deriving the transfer function models with the dynamical parameters depending on the physical parameters of processes. It is also assumed that students have basic skills in synthesis of simple control systems, they understand the meaning of measurement accuracy and its influence on experimental results. They are assumed to know how to apply simple approximation and interpolation as well as numerical integration of simple ordinary differential equations.

16. Course objectives: The course is dedicated to modelling and simulation of industrial processes. Students should know the advanced methods for modelling of complex nonlinear dynamical systems with the stage of tuning model parameters and model verification on the basis of the experimental data. Both the lumped and distributed parameter systems are discussed. The tools for simulation modelled systems are also presented, starting from repetition on numerical integration of ordinary differential equations to the discretization methods for solving partial differential equation. The application of modelling for synthesis advanced control systems as well as state observers is also presented to prepare students to design complex model-based control system on the basis of physical and experimental models.

17. Description of learning outcomes:

Nr	Learning outcomes description	Method of assessment	Teaching methods	Learning outcomes reference code
W1	Meaning of modelling for determining static and dynamical properties of the process is known. Difference between local and global modelling is known.	SP, OS	WT, L	K_W02, K_W12, K_U08
W2	Methods for identification of the parameters of the static and dynamical models based on experimental (measurement) data are known.	SP, CL, OS	WT, L	K_W04, K_W10, K_W11
W3	The methods of improvement in the control performance by applying advanced model-based control strategies are known.	SP, OS	WT, L	K_W03, K_W14, K_W20
W4	The methods of numerical simulation of the lumped and distributed parameter dynamical systems are known.	SP, CL, OS	WT, L	K_W15
U1	One is able to define the conditions of the identification experiment, including experimental derivation of the static and dynamical characteristics of the process.	SP, CL, OS	WT, L	K_U15, K_U21
U2	One has the ability of the effective tuning and validation of the model based on the experimental (measurement) data.	SP, CL, OS	WT, L	K_U15
U3	One is able to prepare the simulation program for numerical simulation of the industrial processes of different complexity.	CL, OS	WT, L	K_U09

U4	One is able to choose appropriate model-based controller to provide improvement in the control performance	CL, OS	WT, L	K_U16, KU_17
K1	One is able to make the decisions about choosing the best solutions for effective modelling of the industrial systems of different complecity.	CL, OS	WT, L	K_K02, K_K05, K_U01
K2.	One has the ability of providing the successful and convincing presentation of the suggested form of the model.	OS, CL	L	K_K03, K_K07, K_U01, K_U03, K_U04

18. Teaching modes and hours

Lecture / BA /MA Seminar / Class / Project / Laboratory

Sem 2: 30 h/lecture., 30 h/laboratory

19. Syllabus description:

Lecture :

Lectures consists of the following topics:

1. Classification of models, local and global modelling.
2. Identification experiments – classification, step response approximation, input-output characteristic approximation.
3. Model synthesis as the iterative process (model structure, tuning and validation, modelling accuracy).
4. Simulation as the experiment with a model, classification of simulation methodologies, real time simulation, batch simulation.
5. Repetition on deriving the simple physical nonlinear models on the basis of the mass and energy conservation laws, steady state calculations.
6. Modelling of the complex dynamical systems including biochemical reactions and the heat exchange and distribution processes.
7. Repetition on the problems of the local modelling by the linear state equations model and by the transfer function model, accuracy of linear modelling, simplified modelling.
8. Correlation between the dynamical parameters of the transfer function and the physical parameters of the nonlinear process model.
9. Nonlinear modelling, nonstationary linear and nonlinear modelling, Wiener and Hammerstein models.
10. Identification experiments, collecting the measurement data for the tuning of the model parameters, the tuning procedure, validation of the model, model uncertainty, adaptive models.
11. Repetition on the simple methods for numerical integration of the ODE nonlinear systems.
12. One step and multistep methods for numerical integration of the ODE nonlinear systems.
13. Application of z-transform for process simulation.
14. Methods for synthesis of the models for distributed parameter systems.
15. Numerical methods of solving the PDE models (Continuous Time-Discrete Space and Discrete Time-Discrete Space methods).
16. Application of the modelling for the monitoring and the advance process control (the idea of the state observers: Luenberger state observer, Kallman filter).
17. Gain scheduling technique on the basis of the nonlinear dynamical model of the process.
18. Model –based control: basic informations, classification, the idea of PMBC (Process Model-Based Control), linearizing control.
19. The basic idea of predictive control: prediction of the process bahaviour on the basis of its model, linear prodictors, nonlinear predictors, parameters of predictive controllers.

Laboratory :

The laboratory classes are strictly correlated with the topics discussed during lectures and the students have the possibility of modelling and simulation of three different industrial systems represented by the laboratory plants equipped with the industrial actuators and measurement devices.

The list of processes with short description is presented below and it corresponds to the particular laboratory blocks, each consisting of 4 laboratory exercises:

1. Block 1: heat exchange and distribution laboratory plant (physical modelling of the electric flow heater as the lumped system, modelling of heat transport witth heat lost as the distributed parameter system, modelling of the nonlinear regulation valve as the simple nonlinear first order element).
2. Block 2: neutralization pilot plant (preparation of identification experiments, modeling of the neutralization process as the nonlinear dynamical lumped system, input-output characteristic of the neutralization process, modeling of the industrial pump, application of the pump model to its model-based control).
3. Block 3: sedimentation pilot plant (modelling of the sedimentation process, modelling of settling velocity function for solid particles and determining its parameters, comparison between different sedimentation models, measurements in the sedimentation process, control of the sedimentation process on the basis of its physical simplified model).

Each block consists of the following stages::

a) Introduction to the particular laboratory pilot plant, defining the modelling goals.

b) Identification experiments for the particular systems, collecting the appropriate measurement data.

c) Tuning of the models and their experimental validation.

d) Synthesis of the model-based controllers where it is required.

e) Discussion on the results.
f) Preparation of the report.

20. Examination: no

21. Primary sources:

1. Douglas J.M., Process Dynamics and Control, Vol. 1., Prentice-Hall, Inc., 1972
2. Metzger M., Modelling, simulation and control of continuous processes. Edition of Jacek Skalmierski Computer Studio, Gliwice, 2000.
3. Franks R.G.E., Modeling and Simulation in Chemical Engineering, John Wiley & Sons, Inc., 1972
4. Luyben W.L., Process Modeling, Simulation and Control for Engineers, McGraw-Hill Inc., 1973

22. Secondary sources:

1. Bastin G., Dochain D., „On-line estimation and adaptive control of bioreactors", Elsevier, 1990, egzemplarz dostępny u prowadzącego.
2. Henson M.A., Seborg D.E., "Nonlinear Process Control", Prentice Hall PTR, 1997.

23. Total workload required to achieve learning outcomes

Lp.	Teaching mode :	Contact hours / Student workload hours
1	Lecture	30/0
2	Classes	0/0
3	Laboratory	30/20
4	Project	0/0
5	BA/ MA Seminar	0/0
6	Other	10/10
	Total number of hours	70/30

24. Total hours:100

25. Number of ECTS credits: 4

26. Number of ECTS credits allocated for contact hours: 2

27. Number of ECTS credits allocated for in-practice hours (laboratory classes, projects): 2

26. Comments:

Approved:

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(date, Instructor's signature) (*date , the Director of the Faculty Unit signature)*