FACULTY OF PURE AND APPLIED MATHEMATICS
SUBJECT CARD

Name of subject in Polish: **Optymalne sterowanie**
Name of subject in English: Optimal control
Main field of study (if applicable): APPLIED MATHEMATICS
Specialization (if applicable): MODELLING, SIMULATION, OPTIMIZATION
Level and form of studies: ~~1st/~~ 2nd level, ~~uniform magister studies~~*, full-time / ~~part-time~~*
Kind of subject: ~~obligatory /~~ optional ~~/ university-wide~~*
Subject code
Group of courses YES / ~~NO~~*

	Lecture	Classes	Laboratory	Project	Seminar
Number of hours of organized classes in University (ZZU)	30		30		
Number of hours of total student workload (CNPS)	90		60		
Form of crediting	crediting with grade				
For group of courses mark (X) final course	X				
Number of ECTS points	3		2		
including number of ECTS points for practical classes (P)	1		3		
including number of ECTS points corresponding to classes that require direct participation of lecturers and other academics (BU)	3				

PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. The student has basic knowledge of calculus, algebra and the probability theory.

SUBJECT OBJECTIVES

C1 Understanding the concepts and methods of control.
C2 Understanding the wording optimal control tasks.
C3 Knowledge of the backgrounds for the analysis of dynamic systems.
C4 Understanding models and analysis of stochastic control systems.
C5 Application of acquired knowledge to create and analyze mathematical models to solve theoretical and practical problems in various fields of science and technology.

SUBJECT EDUCATIONAL EFFECTS

relating to knowledge the student:
PEU_W01. Student knows the formulation of operational research problems.
PEU_W02. He recognizes situations that require the application of operations research methods to solve practical problems.
PEU_W03. He knows the limitations of analytical methods and the possibility of numerical analysis of dynamic models.
PEU_W04. He knows the stochastic methods in operations research.

relating to skills the student:
PEU_U01. Student is able to formulate modeling task for analysis in a convenient form.
PEU_U02. He can use the appropriate algorithm to solve tasks in the operational research.
PEU_U03. Student is able to recognize issues that competent optimization methods are based on the use of stochastic camera.

relating to social competences the student:
PEK_U01 The student is able to find and use the recommended literature course and independently acquire knowledge
PEK_U02 The student is able to use the basic tools for the analysis of mathematical models
PEK_U03 The student understands the need for systematic and independent work on mastery of course material.

PROGRAMME CONTENT		
Lectures		**Hours load**
Lec1	Deterministic control system with discrete time. Algorithm of dynamic programming.	2
Lec2	Processes with discrete time. Markov chains. Conditional expectation. Martingales and Markov times.	2
Lec3	Markov decision processes. Bellman equation.	2
Lec4	Introduction to models with infinite horizon. Markov decision models with discounted payments, minimizing the average cost per unit and other criteria.	4
Lec5	Applications Markov decision processes in the reliability theory, the renewal theory, the queue theory.	2
Lec6	Optimal control of the continuous time. The Hamilton-Jacobi-Bellman equation.	2
Lec7	Linear systems with quadratic cost function and a complete state observation. The inventory control systems.	2
Lec8	Systems with uncertain state observation. Iterative determination of the value functions.	2
Lec9	The approximated solution of the Bellman equation.	2
Lec10	Optimal stopping of finite sequences.	2
Lec11	Optimal stopping of finite Markov sequences. Examples.	2
Lec12	Infinite horizon optimal stopping problem.	2
Lec13	The disorder detection problem.	2
Lec14	Suboptimal solutions of operation models. Adaptive systems.	2
	Total hours	30

Laboratory		**Number of hours**
La1	Examples of deterministic control systems with discrete time.	2
La2	Properties of Markov chains and their analysis. Checking stationarity and ergodicity of stochastic sequences. Classification of states. Conditional expectation. Martingales and Markov moments.	2

La3	Markov decision process for selected practical problems. Analysis of the Bellman equation for the constructed MDPs.	2
La4	Investigation of infinite horizon models. Markov decision models with discounted payoffs, the average cost per unit, and other criteria.	4
La5	Applications Markov decision processes in the reliability theory, the renewal theory, the queue theory-examples.	2
La6	Optimal control of the continuous time. The Hamilton-Jacobi-Bellman equation.	2
La7	Linear systems with quadratic cost function and a complete state observation. The inventory control systems.	2
La8	Systems with uncertain state observation. Iterative determination of the value functions.	2
La9	The approximated solution of the Bellman equation.	2
La10	Optimal stopping of finite sequences.	2
La11	Optimal stopping of finite Markov sequences. Examples.	4
La12	Analysis of selected disorder problems.	2
La13	Suboptimal solutions. Adaptive systems.	2
	Total hours	30

TEACHING TOOLS USED
N1. Lecture - traditional method. N2. Exercise and accounting problems - the traditional method. N3. Consultation. N4. Student's own work - preparing to exercise and test.

EVALUATION OF SUBJECT EDUCATIONAL EFFECTS ACHIEVEMENT

Evaluation (F – forming (during semester), P – concluding (at semester end)	Educational effect number	Way of evaluating educational effect achievement
F1	PEU_W01, PEU_W02, PEU_W03 PEU_W04, PEU_W05 PEU_K01, PEU_K02	oral presentations, quizzes, tests
F2	PEU_W01, PEU_W02, PEU_W03 PEU_W04, PEU_W05 PEU_U01, PEU_U02, PEU_U03, PEU_U04 PEU_K01, PEU_K02, PEU_K03	exam
P=0,4*F1+0,6*F2		

PRIMARY AND SECONDARY LITERATURE
PRIMARY LITERATURE:
[2] Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, vol. 1, Athena Scientific, Belmont, MA: 2005.
[3] Dimitri P. Bertsekas, Dynamic Programming and Optimal Control, vol. 2, Athena Scientific, Belmont, MA: 2007.
[4] Harold Kushner: Wprowadzenie do teorii sterowania stochastycznego. WNT, 1983.

[5] A.N. Shiryaev. Optimal Stopping Rules. Springer-Verlag, New York, Heidelberg, Berlin, 1978.

SECONDARY LITERATURE:

[1] J. P. Aubin, Optima and Equilibria. An Introduction to Nonlinear Analysis, Springer, Berlin 1993.

[2] Wayne l. Winston: introduction to mathematical programming: applications and algorithms, 1991.

SUBJECT SUPERVISOR (NAME AND SURNAME, E-MAIL ADDRESS)

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