# DOCTORAL SCHOOL OF WROCŁAW UNIVERSITY OF SCIENCE AND TECHNOLOGY

SUPERVISOR/TEAM/ DECLARING/CONDUCTING COURSE: Mirosław Łukowicz Ph.D. D.Sc…………………………….
DEPARTMENT K2/W5……………….

## COURSE CARD

**Course name in Polish:** Teoria Sterowania Optymalnego ………………….………..
**Course name in English: Optimal Control Theory** ………………………..………
**Course language Polish / English\***
**University-wide general course type\*:**
1) basic science course (mathematics, physics, chemistry, computer science or other) :


**Specialized courses for PhD students receiving education in discipline\*: ……………………….……………………………………….………………………**
1) specialized course in discipline: …………………………………………………………..
2) interdisciplinary course in the field of several disciplines: …………………………………
3) seminar in discipline or interdisciplinary: …………………………………………………….

**Subject code:** AEQ100147W

\* delete as applicable

| | Lecture | Foreign language course | Seminar | Mixed forms |
|---|---|---|---|---|
| Number of hours of organized classes in university (ZZU) | 30 | | | |
| Grading | Exam | Exam | Oral presentation | Exam, inspection, evaluation classes |

## PREREQUISITES RELATING TO KNOWLEDGE, SKILLS AND OTHER COMPETENCES

1. Knowledge of the concepts used in automation, as well as types of control systems, and description and characteristics of automation components and systems. Basic knowledge about automatic control systems.

2. Ability to analyze simple automatic control systems and prepare and transform block diagrams of automation systems.

3. Ability to work independently

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## COURSE OBJECTIVES
C1 Ability to formulate and solve optimal control tasks

| PROGRAM CONTENTS |
|---|

| Form of classes – lecture (Lec) | | Number of hours |
|---|---|---|
| Lec1 | **Models of control systems** | 2 |
| Lec2 | **Optimal control - deterministic problems**<br>*Optimal control of static objects* | 2 |
| Lec3 | *Discrete control of dynamic objects - dynamic programming.* | 2 |
| Lec4 | *Application of the Lagrange multipliers method in dynamic programming* | 2 |
| Lec5 | *Continuous optimal control in an open system. The principle of optimality. The Bellman equation.* | **2** |
| Lec6 | *Pontryagin's maximum principle. Minimal-time control under limited control signal.* | **2** |
| Lec7 | *Linear-quadratic problem.* | **2** |
| Lec8 | **Optimal control - probabilistic problems**<br>*Estimation of an unknown parameter measured in the presence of disturbances.*<br>*Estimation of an unknown parameter based on least squares method.* | **2** |
| Lec9 | *Optimal control - probabilistic problems*<br>*The maximum likelihood method. The minimum risk method.* | **2** |
| Lec10 | *Optimal control of the discrete dynamic object in the presence of disturbances* | **2** |
| Le11 | **Extreme control**<br>*Extreme control in the probabilistic version* | **2** |
| Lec12 | **Artificial intelligence and knowledge representation in control systems**<br>*ANNs and backpropagation algorithm* | **2** |
| Lec13 | **Analysis and synthesis of linear control systems for random stationary interferences**<br>*General characteristics of stochastic stationary processes* | **2** |
| Lec14 | *Analysis of a linear dynamic system with stationary stochastic disturbances* | **2** |
| Lec15 | *Parametric optimization of a linear control system with stationary stochastic disturbances.*<br>*Non-parametric optimization of a linear control system with stationary stochastic disturbances* | **2** |
| | **Sum of hours** | **30** |

| TEACHING TOOLS USED |
|---|
| N1. Multimedia presentation<br>N2.<br>N3. |

| ACHIEVED SUBJECT LEARNING OUTCOMES | | |
|---|---|---|
| Type of learning outcome | Code of learning outcome | Assessment of learning outcome |

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| Knowledge | PEK_W01 | exam |
|---|---|---|
| Skills | PEK_U01 | exam |
| Social competence | PEK_K01 | exam |

## PRIMARY AND SECONDARY LITERATURE

### PRIMARY LITERATURE:

[1]   Bubnicki Z., Teoria i algorytmy sterowania, PWN, Warszawa  2002.
[2]   Kirk E.D, Optimal control theory. An introduction, Dover Publications, Inc. Mineola, New York, 2004.

### SECONDARY LITERATURE:

[1]   Philippe de Larminant, Yves Thomas., Automatyka-układy liniowe. T. I, II, III.

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

**Mirosław Lukowicz; miroslaw.lukowicz@pwr.edu.pl**