Cracow University of Technology

# Course syllabus

binding for the doctoral students of the CUT Doctoral School commencing their studies in the academic year 2022/2023

## Information on the course

| | |
|---|---|
| Name of the course in Polish | Metodyka analizy elektromechanicznych przetworników energii |
| Name of the course in English | Methodology for analysis of electromechanical energy converters |
| Number of the ECTS points | 2 |
| Language of instruction | Polish |
| Category of the course | Elective |
| Field of education | Engineering and Technology |
| Discipline of education | Automatic Control, Electronics and Electrical Engineering |
| Person responsible for the course<br>Contact | Prof. Tadeusz J. Sobczyk, *doctor habilitatus* in Engineering<br>tadeusz.sobczyk@pk.edu.pl |

## Type of course, number of hours in the study programme curriculum

| Semester | Credit type (G / NG)* | Lecture | Practical class | Laboratory | Computer laboratory | Project class | Seminar |
|---|---|---|---|---|---|---|---|
| 2 | G | 30 | 0 | 0 | 0 | 0 | 0 |

*G – graded credit, NG – non-graded credit

## Course objectives

| Code | Objective description |
|---|---|
| Objective 1 | Introduction to the problems of advanced modelling and analysis of electromechanical energy converters |
| Objective 2 | Presentation of formulation and analysis of advanced mathematical models of induction machines |

## Learning outcomes

| Code | Description of the learning outcome adjusted to the specific characteristics of the discipline | Learning outcome symbol in the CUT DS | Methods of verification |
|---|---|---|---|
| OUTCOMES RELATED TO KNOWLEDGE | | | |
| EUW1 | The doctoral student knows and understands the theoretical foundations for the formulation of mathematical models of electromechanical energy converters. | E_W01<br>E_W02 | Attendance at lectures,<br>written assessment |
| EUW2 | The doctoral student knows and understands advanced methods for solving mathematical models of electromechanical energy converters. | E_W01<br>E_W02 | Attendance at lectures,<br>written assessment |
| OUTCOMES RELATED TO SKILLS | | | |

| | | | |
|---|---|---|---|
| EUU1 | The doctoral student is able to take into account in mathematical models certain features of the magnetic circuit structure and of the windings of electromechanical energy converters. | E_U01 | Attendance at lectures, written assessment |
| EUU2 | The doctoral student is able to determine the properties of electromechanical energy converters based on the solutions of mathematical models. | E_U02 | Attendance at lectures, written assessment |
| OUTCOMES RELATED TO SOCIAL COMPETENCES | | | |
| EUK1 | The doctoral student is able to critically evaluate professional literature and appreciate mathematical methods for acquiring knowledge about the properties of technical objects. | E_K01 E_K03 | Written assessment |

**Course outline**

| No. | Contents | Learning outcomes for the course | No. of hours |
|---|---|---|---|
| LECTURE | | | |
| W1 | The general form of the Lagrange and Hamilton equations of electromechanical systems. The significance of energy functions and their forms. The characteristics of the equations of electromechanical energy converters and the reasons for the difficulty of solving them. The classification of operating states in relation to methods of analysis. | EUW1, EUW2, EUU1 | 8 |
| W2 | Applications of linear transformations to simplify equations of electromechanical systems. Conditions for reduction to linear equations with constant coefficients. Forms of general and particular solutions for such equations. Examples of analysis and solution of equations of simple energy converters. | EUW1, EUW2, EUU1, EUK1 | 4 |
| W3 | Analysis of electromagnetic phenomena in electromechanical rotary motion converters based on linear differential equations with periodic-variable coefficients. Basic properties of general and particular solutions of such equations. Introduction to the harmonic balance method. Applications to the steady-state analysis of AC electrical machines. Examples of qualitative analysis of Fourier spectra of simple electromechanical converters using the harmonic balance method. | EUW2, EUU1, EUU2, EUK1 | 5 |
| W4 | An example of the application of various analysis techniques to determine the properties of ring machines in transient and steady-state conditions when considering higher harmonic flows in windings. | EUU1, EUU2 EUK1 | 4 |
| W5 | Analysis of the properties of squirrel-cage induction machines using transformation matrix and the harmonic balance method. | EUU1, EUU2, EUK1 | 5 |
| W6 | Problems of solving harmonic balance equations for AC machines. The LU decomposition method and the discrete harmonic balance method. | EUW1, EUK1 | 4 |

**The ECTS points statement**

| WORKING HOURS SETTLEMENT | |
|---|---|
| Type of activity | Average number of hours (45 min.) dedicated to the completion of an activity type |
| SCHEDULED CONTACT HOURS WITH THE ACADEMIC TEACHER | |
| Hours allotted in the syllabus | 30 |
| Consultations | 2 |
| Course credit assignment | 3 |
| HOURS WITHOUT THE PARTICIPATION OF THE ACADEMIC TEACHER | |
| Independent study of the course contents | 20 |
| Preparation of a paper, report, project, presentation, discussion | 0 |
| ECTS POINTS STATEMENT | |
| Total number of hours | 55 |
| The ECTS points number | 2 |

**Preliminary requirements**

| No. | Requirements |
|---|---|
| 1 | Knowledge of the fundamentals of algebra, mathematical analysis and differential equations. |
| 2 | Knowledge of the basic concepts, laws and methods of electrical circuit theory, electromagnetic circuit theory and electromechanical system theory. |

**Course credit assignment conditions / method of the final grade calculation**

| No. | Description |
|---|---|
| COURSE CREDIT ASSIGNMENT CONDITIONS | |
| 1 | 80% attendance in class. Successful completion of the written assessment. |
| METHOD OF THE FINAL GRADE CALCULATION | |
| The grade obtained on the written assessment. | |

**Additional information**

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| None |

**The course reading list**

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|---|---|
| 1 | Sobczyk T.J.; Metodyczne aspekty modelowania matematycznego maszyn indukcyjnych, WNT, Warszawa, 2002. |
| 2 | Sobczyk T.J., Węgiel T.; Elektromechaniczne przemiany energii, Wyd. PK, Kraków, 2014. |
| 3 | Rusek J.; Komputerowa analiza maszyny indukcyjnej z wykorzystaniem bilansu harmonicznych, Wyd. AGH, Kraków, 2000. |
| 4 | Articles from scientific journals and conferences as indicated by the teacher. |