COURSE DESCRIPTION CARD - SYLLABUS

Course name
Optimisation methods in electromagnetic devices design

Course

Field of study
Electrical Engineering

Year/Semester
1/2

Area of study (specialization)
Drive Systems in Industry and Electromobility

Profile of study
general academic

Level of study
Second-cycle studies

Course offered in
English

Form of study
full-time

Requirements
elective

Number of hours

Lecture
15

Laboratory classes

Other (e.g. online)

Tutorials

Projects/seminars
15

Number of credit points

2

Lecturers

Responsible for the course/lecturer:
dr inż. Łukasz Knypiński
email: lukasz.knypinski@put.poznan.pl
tel. 61 665 2636
Faculty of Control, Robotics and Electrical Engineering

Responsible for the course/lecturer:

Prerequisites

The student starting this subject should have basic knowledge of mathematical analysis, linear algebra and vectorial calculus. He should also have the ability to formulate a design task at the engineering level and the ability to computer programimng at the general level.

The ability of effective self-education is required by obtaining information from indicated sources and the awareness of the need to expand their competences and readiness to cooperate within a team.

Course objective

Acquiring the skills to correctly formulate a synthesis task of a technical devices and to optimize such devices. Getting the knowledge about deterministic and non-deterministic methods of unconstrained optimization.

Acquiring knowledge about methods of considering the technical and economical constraints.

Student should gain ability of the identification and formulating tasks of the multi-criteria optimization. He should also acquiring the ability of the selection of the algorithm of the optimization to the solved the put problem.

Course-related learning outcomes

Knowledge

1. Student has an expanded and deepened knowledge in some branches of mathematics, including elements of discreet and applied mathematics, necessary for modeling and analyzing the operation of advanced electrical devices and systems, as well as description and analysis of the operation and synthesis of complex electrical systems

2. Student has an extended knowledge of advanced numerical methods used to solve complex technical problems in electrical engineering.

3. Student has a knowledge in the field of designing electrical devices and systems, taking into account their impact on the environment.

4.Student has a extended knowledge of high-level programming using object-oriented programming elements.

5.Student has a extended knowledge of computer-aided design in electrical engineering.

Skills

1. Student is able to search information from literature, databases and other sources, make their interpretation, evaluation, critical analysis and synthesis, as well as draw conclusions and formulate opinions.

2. Student is able to use methods and mathematical models for analysis and designing electrical devices and systems.

3. Student is able to use the known methods and mathematical models to analyze and design processes, devices and electrical systems.

4. Student is able to design and manufacture elements as well as complex electrical devices and systems, taking into account the permissible criteria (utility and economic), if necessary, adapting the existing or developing new methods, techniques and computer-aided design tools

5. Student is able to formulating and solving engineering tasks - to integrate knowledge from various sources and related disciplines, and to use analytical, simulation and experimental methods.

Social competences

1. The student understands the need of formulating both handing over to the society information and opinions of achievements in the area of electrical engineering and other aspects of activity of an electrical engineer.

Methods for verifying learning outcomes and assessment criteria

Learning outcomes presented above are verified as follows:

Lecture:
- assessment of knowledge and skills demonstrated in the written exam of a problem nature,
- continuous assessment during each class (rewarding activity and quality of perception).

Project:
- checking and rewarding knowledge necessary to implement the problems raised,
- evaluation based on current progress of project implementation in the form of computer programs.

Getting extra points for activity during classes, especially for:
- proposing to discuss additional aspects of the issue;
- effectiveness of applying the acquired knowledge when solving a given problem;
- comments related to the improvement of teaching materials.

Programme content

Lecture:

Electromagnetic device synthesis, formulation of the device optimization problem: decision variables, objective function, constrain functions. Normalization of variables and functions. Deterministic method of unconstrained optimization. The gradient procedures, conjugate gradient algorithms. Algorithms of direction optimization.

Heuristic algorithms: genetic algorithm, particle swarm optimization, bat algorithm, gray wolf optimization algorithm and cuckoo search algorithm. Equality constrained optimization Courrant procedure. Inequality constrained methods: external and internal penalty functions. Multi-criteria optimization.

Project:

Formulating the task of unconditional optimization of the technical device - selection of design variables and compromise objective function as well as their normalization. Development of the algorithm and optimization program using a gradientless method. Constrained optimization task - defining nonlinear constraint functions. The development of an algorithm and a program for solving the task of optimal design of an electromagnetic device with constraints taken into account by the method of the function of external penalty in connection with the gradient method of unconditional optimization. Solution of the test problem with the use of the genetic algorithm.

Teaching methods

Lecture:

- lecture with multimedia presentation supplemented with examples given on the board,
- lecture conducted in an interactive way with the formulation of questions to a group of students and taking into account the activity of students during classes when issuing the final grade,
- discussion of various aspects of solved problems, including: economic, ecological, legal, social.

Project:

analysis of different methods to solve the problem,
- developing and implementing an effective computer program to optimize the selected technical object,
- multimedia shows.

Bibliography

Basic

1. Podstawy optymalizacji, A. Stachurski, A. Wierzbicki, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2001

2. Optymalizacja, Wybrane metody z przykładami zastosowań, J. Kusiak, A. Danielewska-Tułecka, P. Oprocha, PWN, Warszawa 2009

3. Teoria i metody obliczeniowe optymalizacji, Findeisen W., Szymanowski J., Wierzbicki A., Państwowe Wydawnictwo Naukowe, Warszawa, 1977

4. Algorytmy genetyczne i ich zastosowania, D.E. Goldberg, WNTWarszawa,1998

5. Optymalizacja i polioptymalizacja w mechatronice. Wojciech Tarnowski, Wydawnictwo Uczelniane PolitechnikiKoszlińskiej, Koszalin 2009

Additional

Additional bibliography:

1. Global optimization, Torn A., Zilinskas A., Springer Verlag, Berlin, 1987

2. Wykłady z Modelowania Matematycznego, Wybrane algorytmy optymalizacji, Algorytmy genetyczne, Algorytmy mrówkowe R. Grzymkowski, K. Kaczmarek, St. Kiełtyka, I. Nowak, Pracownia Komputerowa Jacka Skalmierskiego Gliwice 2008 .

3. Genetic algorithms in search, optimization and machine learning, Goldberg E.D., Addison Wesley Publishing Company, Inc., 1989

4. Multiobjective shape design in electricitry and magnetism, Paolo Di Barba, Lecture notes in electrical Engineering, Springer, 2017.

5. Optimization of the rotor geometry of line-start permanent magnet synchronous motor by the use of particle swarm algorithm, Knypiński Ł., Nowak L., Jędryczka C., COMPEL - The International Journal For Computation and Mathematics in Electrical and Electronic Engineering, Vol. 34, No. 3, pp. 882-892, 2015.

6. Zastosowanie algorytmu szarych wilków do rozwiązania zadań optymalizacji urządzeń elektromagnetycznych, Ł. Knypiński, L. Nowak, Poznań University Academic Journals. Electrical Engineering, no. 100, s. 133 – 144, 2019.

7. Oprogramowanie do wyznaczania kształtu impulsu napięciowego zasilającego silnik BLDC wykorzystujące metodę poszukiwania kukułczego, Ł. Knypiński, S. Kuroczycki, M. Kurzawa, Poznań University Academic Journals. Electrical Engineering, no. 106, s. 17 – 21, 2021.

8.Optimal design of the rotor geometry of line-start permanent magnet synchronous motor using the bat algorithm, Ł. Knypiński, Open Phisycs, vol. 15, no.1, pp. 965 – 970, 2017.

9. Minimization of Torque Ripple in the Brushless DC Motor Using Constrained Cuckoo Search Algorithm, Ł. Knypiński, S. Kuroczycki, F. P. G. Marquez, Electronics, vol. 10, no. 18, s. 2299-1-2299-20, 2021

Breakdown of average student's workload

	Hours	ECTS
Total workload	58	2,0
Classes requiring direct contact with the teacher	30	1,0
Student's own work (literature studies, preparation for laboratory classes/tutorials, preparation for tests/exam, project preparation) [1]	28	1,0

[1] delete or add other activities as appropriate