Detailed course description
(SUBJECT CARD)

Course title: Applied mathematics in modeling of energy processes
Course code:
Classification of a course group:
Course type: basic
obligatory
Field of study: ENERGY ENGINEERING ET
Level of study: second-cycle
Profile of study: general academic
Mode of study: full-time programme
Specialty (specialisation): Energy Transition
Year of study: 1
Semester: **winter**
Teaching modes and teaching hours:
lectures – 30;
laboratory – 30;
Language/s of instruction: english
Number of ECTS credits *(according to the study programme)*: **4**
** – leave the appropriate option*

1. Course objectives: To provide students with basic methods of optimization and solving of differential equations encountered in analysis of engineering problems.
2. Relation of the field-related learning outcomes to modes of teaching and methods of verification as well as to assessment of student's learning outcomes:

symbol	assumed learning outcomes *a student who completed the course:*	teaching modes	verification methods and learning outcomes assessment
Knowledge: a student knows and understands			
K2A_W05	demonstrates broad and deep knowledge of mathematics, physics and other areas, used for formulating and solving complex tasks specific to the field of Power Engineering	Lecture	Solving case during lecture/written test
K2A_W07	is familiar with advanced numerical methods and procedures, as well as programming concepts and computing capabilities	Lecture	Solving case during lecture/written test
Skills: a student can			
K2A_U08	uses modern computer software in engineering tasks and basic research problems related to construction of machines, equipment and modelling of electric power systems	Laboratory	Solving project problem
K2A_U09	builds complex models of technological processes, as well as analyses them by using analytical, experimental methods and conducts simulations of those processes	Laboratory	Solving project problem
K2A_U19	uses mathematical methods in solving engineering problems and basic research tasks regarding physical and chemical processes in the field of power engineering	Laboratory	Solving project problem
K2A_U20	uses commercial calculation software and creates his/her own computer tools for mathematical modelling purposes	Laboratory	Solving project problem
K2A_U23	uses advanced methods facilitating the process of solving practical technical and economic problems in the field of power engineering	Laboratory	Solving project problem

3. The content of study programme ensuring learning outcomes *(according to the study programme)*:

   Basics of optimization. Design variables. Building the objective function. Equality and inequality constrains. Minimization of function dependent on one or many variables without and with constrains. Basic information on genetic and evolutionary algorithms.

   Basics of differential equations. Methods of solving ordinary and partial differential equations. Fundamental analytical methods of differential equations solution. Most popular numerical methods (Euler's method, Euler's-Cauchy's method, Runge's-Kutta's method). Solution methods of the differential equation set.

4. Description of methods of determination of ECTS credits:

Type of activity	Number of hours / ECTS credits
Number of course hours regardless of a teaching mode	60/2

Case study for lecture	15/0,5
Work on project	30/1
Presentation preparation	15/0,5
Total hours:	**120**
Number of ECTS credits allocated to a course	**4**

Explanation:
˚ – student's workload - fill in the types of activities, e.g. *preparation for a course, interpretation of results, making a course report, preparation for an exam, studying sources, making a project, presentation* and *report, doing written assignment, etc.*
˚˚ – the other e.g. *extra course hours*

5. Summary indexes:
   - number of course hours and ECTS credits at the course with a direct participation of academic teachers or other persons running the course and supervising students; 60/2
   - number of course hours and ECTS credits at the course related to the scientific activity conducted at the Silesian University of Technology in a discipline or in disciplines to which a field of study is assigned - in the case of studies with a general academic profile; 60/2
   - number of course hours and ECTS credits at the course developing practical skills- in the case of practical studies;
   - number of course hours conducted by academic teachers employed by the Silesian University of Technology as their primary workplace. 60
6. Persons conducting particular modes of courses (name, surname, academic degree or degree in arts, title of professor, business e-mail address):

   Lecture: Arkadiusz Ryfa, dr inż., Arkadiusz.Ryfa@polsl.pl

   Project: Arkadiusz Ryfa, dr inż. , Arkadiusz.Ryfa@polsl.pl
7. Detailed description of teaching modes:

   1) lectures:

      – detailed programme's content:

      What is optimization and why it is so important for modern engineer. Description of the nature of optimization. Design variables. Presentation of ways of building the objective function. Importance of constrains - equality and inequality constrains. Ways of selecting proper optimization methods. Minimization of function dependent on one variable. Minimization of function dependent on many variables without and with constrains. Genetic and evolutionary algorithms – their nature, pros and cons – when they should be used.

      Differential equations – why they are used and how they describe various physical phenomena. Methods of solving ordinary and partial differential equations. Fundamental analytical methods of differential equations solution. Most popular numerical methods (Euler's method, Euler's-Cauchy's method, Runge's-Kutta's method). Solution methods of the differential equation set.

      – teaching methods, including distance learning:

      Introduction and basic information will be given through multimedia presentation. Three case-study will be done during lecture to activate students and to allow them better understanding the applicability of theoretical knowledge. Presentations and all other teaching materials will be available online through educational platform at SUT.

      – form and criteria for semester completion, including retake tests, as well as conditions for admission to the examination:

      Lecture credits will be gained by taking written theoretical test (50%) and case activity (50%). There will be two possibility to retake the tests.

      – course organisation and rules of participation in the course, with an indication whether a student's attendance is obligatory

      Lectures will be handled weekly: 90 minutes per 15 weeks. Attendance is not obligatory.

   2) laboratory:

      During laboratory three problems will be solved: optimization, solving differential equation and application of genetic algorithms in optimization. For problem solving MS Excel with Visual Basic and MatLab will be used.

– teaching methods, including distance learning:

Problems will be solved individually or in pairs. Problem based learning method will be used. Main part of each task will be the problem formulation and data gathering. Each task will be finalized with short written summary and presentation. Presentations and all other teaching materials will be available online through educational platform at SUT.

– form and criteria for semester completion, including retake tests, as well as conditions for admission to the examination

Final grade from laboratory will be an average from three taksa. Grade from each task will be calculated as weighted average for: of work during classes (35%), for summary (35%) and for presentation (30%).

8. Description of the method for determining the final grade (rules and criteria for evaluation, as well as the final grade calculation method in the case of a course comprising more than one teaching mode, taking into account all teaching modes and all exam dates and credit tests including retake exams and tests):

   Final grade from subject will be calculated as weighted average of laboratory (60%) and lecture (40%).

9. Method and procedure for making up for

   - student's absence from the course – individual consultations

   - differences in study programmes for students changing their field of study, changing university or resuming studies at the Silesian University of Technology - individual consultations and additional work with books/other knowledge sources

10. Prerequisites and additional requirements, taking into account the course sequence:

    Mathematics – solving systems of equations, interpolation and approximation. Basic physics. Basic heat transfer.

11. Recommended sources and teaching aids:

    Ryfa A., Lecture notes.

    Press W.H., Teukolsky S.A, Vetterling W.T, Flannery B.P: Numerical Recipes in Fortan. Cambridge University Press, 1994

    Turunen E., Raivio K., Mantere T. (2016) Soft Computing Methods. In: Pohjolainen S. (eds) Mathematical Modelling. Springer, Cham

    Tuomela J. (2016) Modelling with Differential Equations. In: Pohjolainen S. (eds) Mathematical Modelling. Springer, Cham

12. Description of teachers' competences (e.g. publications, professional experience, certificates, trainings etc. related to the programme contents implemented as a part of the course):

    Almost 20 years of experience in teaching at academic level. Working with numerical methods and optimization for over a decade. Participated in CISM course on soft computing methods. Participated in courses on Case Teaching, Project Based Learning, Case Teaching – case development.

13. Other information:
    No other information.