



Modelling of Physical Systems

Course description sheet

Basic information

<p>Field of study Computer Science and Intelligent Systems</p> <p>Major Artificial Intelligence and Data Analysis</p> <p>Organisational unit Faculty of Electrical Engineering, Automatics, Computer Science and Biomedical Engineering</p> <p>Study level Second-cycle (engineer) programme</p> <p>Form of study Full-time studies</p> <p>Profile General academic</p>	<p>Didactic cycle 2025/2026</p> <p>Course code EISIAIDAS.IIi1.05797.25</p> <p>Lecture languages English</p> <p>Mandatoriness Obligatory</p> <p>Block Core Modules</p> <p>Course related to scientific research Yes</p>	
Course coordinator	Miroslaw Zimnoch	
Lecturer	Miroslaw Zimnoch, Piotr Sekula	
Period Semester 1	<p>Method of verification of the learning outcomes Completing the classes</p> <p>Activities and hours Lectures: 14 Laboratory classes: 14 Project classes: 14</p>	Number of ECTS credits 3

Course's learning outcomes

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
Knowledge - Student knows and understands:			

Code	Outcomes in terms of	Learning outcomes prescribed to a field of study	Methods of verification
W1	Student has a deepened knowledge of mathematical foundations of different approaches to the modelling of physical systems.	ISI2_W01	Participation in a discussion, Execution of a project, Execution of laboratory classes
W2	Student has a deepened knowledge of selected models of physical phenomena.	ISI2_W02	Participation in a discussion, Execution of a project, Execution of laboratory classes
Skills - Student can:			
U1	Student is able to formulate a mathematical model of a complex physical problem using appropriate principles of Physics.	ISI2_U05	Project, Report, Completion of laboratory classes
U2	Student is able to develop and analyse in a detailed and critical manner a sophisticated mathematical model.	ISI2_U03	Project, Report, Involvement in teamwork, Completion of laboratory classes

Program content ensuring the achievement of the learning outcomes prescribed to the module

Methodical aspects of numerical modeling Applications and limitations of methods Modelling of physical processes Modelling of environmental components

Student workload

Activity form	Average amount of hours* needed to complete each activity form
Lectures	14
Laboratory classes	14
Project classes	14
Preparation for classes	14
Realization of independently performed tasks	28
Contact hours	5
Student workload	Hours 89
Workload involving teacher	Hours 42

* hour means 45 minutes

Program content

No.	Program content	Course's learning outcomes	Activities
1.	<p>Methodical aspects of numerical modeling:</p> <ul style="list-style-type: none"> • Dynamic and static models, stationary and non-stationary models, models with lumped and distributed parameters. • Design a variety of computational grids. • Defining the boundary and initial conditions. • The simplifications used in the modeling (reduced dimensions, neglecting insignificant factors, etc.) • Stages of numerical modeling. Physical model. Computational model. A mathematical model. Calibration and scaling of the model. The calculation and verification of the results. • Selection of the numerical algorithm for solving the phenomenon (numerical stability, the stability criteria) • Forward and inverse modeling (optimization) 	W2, U1, U2	Lectures, Laboratory classes, Project classes
2.	<p>Applications and limitations of methods:</p> <ul style="list-style-type: none"> • Finite differences, • Finite Element • Monte Carlo • Lump parameter modelling 	W1, U1	Lectures, Laboratory classes, Project classes
3.	<p>Modelling of physical processes:</p> <ul style="list-style-type: none"> • Distribution of stress, deformation • Transport processes (heat, diffusion, advection, convection, etc.) • Energy balance 	W2	Lectures, Laboratory classes, Project classes
4.	<p>Modelling of environmental components:</p> <ul style="list-style-type: none"> • atmosphere • soil-atmosphere interface • rivers and lakes • oceans • groundwater systems 	W2, U2	Lectures, Laboratory classes, Project classes

Extended information/Additional elements

Teaching methods and techniques :

Project classes, Lectures

Activities	Methods of verification	Credit conditions
Lectures	Participation in a discussion	Active participation in discussion during the lectures
Lab. classes	Execution of laboratory classes, Completion of laboratory classes	Participation in laboratory classes Positive grades from all reports
Project classes	Execution of a project, Project, Report, Involvement in teamwork	Submission of project report Presentation of the project on the last meeting Positive evaluation of the report and presentation

Conditions and the manner of completing each form of classes, including the rules of making retakes, as well as the conditions for admission to the exam

Lectures: participation in the discussion.

Laboratory classes: positive evaluation of all partial reports.

Project classes: Submission of the project report, presentation of the project, positive evaluation of the report and presentation.

Method of determining the final grade

Completion of the course is possible when all partial grades are positive.

The final grade is calculated as weighted mean based on laboratory grade (60%) and project grade (40%).

In case of a grade correction, grades of all terms are taken into consideration.

Manner and mode of making up for the backlog caused by a student justified absence from classes

The procedure to compensate the backlog caused by the absence of the student in the classroom:

Absence from one laboratory classes require the student to familiarize yourself with the material discussed in class;

Absence of more than one laboratory classes require the student to familiarize yourself with the material discussed in class and pass a written sentence within a period specified by the teacher but not later than the last week of classes.

The student who, without justification, has left more than 20% of classes and partial academic results were negative may be deprived, by the teacher, the possibility of leveling up.

Prerequisites and additional requirements

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- knowledge of linear algebra (operations on vectors and matrices)
- knowledge of calculus
- knowledge of procedural programming
- knowledge of MATLAB or similar environment is recommended (not required)

Rules of participation in given classes, indicating whether student presence at the lecture is obligatory

Lectures: participation in all lectures is not obligatory.

Laboratories: participation is obligatory, laboratory grade is calculated as an arithmetic mean from partial grades of each exercise.

Project: Project grade is assigned based on final report and presentation during the classes.

Literature

Obligatory

1. Suli E., Mayers D. An Introduction to Numerical Analysis. Cambridge University Press, 2003.
2. Sportisse B., Air Pollution Modelling and Simulation. Springer 2002.
3. Blackadar A.K., Turbulence and Diffusion in the Atmosphere. Springer 1997.
4. Wells N., The atmosphere and Ocean. John Willey & Sons, 1999.

Optional

1. Walker J.C.G. Numerical Adventures with Geochemical Cycles. Oxford University Press, 1991.
2. Praca zbiorowa, Use of Isotopes for Analyses of Flow and Transport Dynamics in Groundwater Systems. IAEA Tech-Doc
3. Griebel M., Knapek S., Zumbusch G. Numerical Simulation in Molecular Dynamics. Springer 2007.

Scientific research and publications

Research

1. Investigation of planetary boundary layer dynamics and atmospheric pollutants transport in urban environment based on the observations and numerical modelling.
2. Assessment of greenhouse gases emissions in urban areas using isotopic tracers and numerical modelling.

Publications

1. Sekula P., Bokwa A., Bochenek B., Zimnoch M., 2019, Prediction of Air Temperature in the Polish Western Carpathian Mountains with the ALADIN-HIRLAM Numerical Weather Prediction System. *Atmosphere* 10, 186; doi:10.3390/atmos10040186
2. Zimnoch M., Necki J., Chmura L., Jasek A., Jelen D., Galkowski M., Kuc T., Gorczyca Z., Bartyzel J. and Rozanski K., 2019, Quantification of carbon dioxide and methane emissions in urban areas: source apportionment based on atmospheric observations. *Mitig Adapt Strateg Glob Change*, 24:1051–1071 <https://doi.org/10.1007/s11027-018-9821-0>

Learning outcomes prescribed to a field of study

Code	Content
ISI2_U03	Absolwent potrafi formułować i weryfikować hipotezy, analizować nieprzewidywalne warunki związane z problemami inżynierskimi i prostymi zagadnieniami badawczymi, szczególnie z uwzględnieniem specyfiki systemów inteligentnych, potrafi opracować specyfikację projektową złożonego oprogramowania systemu inteligentnego, z uwzględnieniem aspektów prawnych oraz innych aspektów pozatechnicznych, z uwzględnieniem norm i standardów, zaprojektować oprogramowanie adekwatnie do specyfikacji wymagań, opracować szczegółową dokumentację wyników, a także przygotować i i przedstawić prezentację oraz przeprowadzić dyskusję wyników
ISI2_U05	Absolwent potrafi wykorzystać poznane metody, algorytmy i modele do tworzenia różnego rodzaju programów o charakterze użytkowym i naukowym, z uwzględnieniem specyfiki specjalności oraz systemów inteligentnych
ISI2_W01	Absolwent ma poszerzoną i ugruntowaną wiedzę i potrafi formułować i rozwiązywać zarówno typowe, jak i nietypowe, w tym złożone, problemy w sposób innowacyjny w oparciu o znajomość w zakresie przedmiotów ścisłych, w szczególności zadania z zakresu informatyki systemów inteligentnych
ISI2_W02	Absolwent ma pogłębioną wiedzę w zakresie specyficznych metod i złożonych struktur danych związanych ze specjalnością, w szczególności w odniesieniu do nietypowych i innowacyjnych problemów systemów inteligentnych, a także wiedzę w odniesieniu do zastosowań metod obliczeniowych oraz wybranych zagadnień systemów inteligentnych