GDAŃSK UNIVERSITY OF TECHNOLOGY

Subject card

Subject name and code	Modelling and optimisation for transportation systems, PG_00064980		
Field of study	Transport and Logistics		
Date of commencement of studies	February 2027	Academic year of realisation of subject	2026/2027
Education level	second-cycle studies	Subject group	Obligatory subject group in the field of study Subject group related to scientific research in the field of study
Mode of study	Full-time studies	Mode of delivery	at the university
Year of study	1	Language of instruction	Polish
Semester of study	1	ECTS credits	3.0
Learning profile	general academic profile	Assessment form	exam
Conducting unit	Division of Hydromechanics and Ship Design -> Institute of Naval Architecture -> Faculty of Mechanical Engineering and Ship Technology -> Faculties of Gdańsk University of Technology		
Name and surname of lecturer (lecturers)	Subject supervisor	dr inż. Marcin Życzkowski	
	Teachers	dr inż. Marcin Życzkowski	

Lesson types

Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
Number of study hours	15.0	0.0	0.0	15.0	0.0	30
E-learning hours included: 0.0						

Learning activity and number of study hours

Learning activity	Participation in didactic classes included in study plan	Participation in consultation hours	Self-study	SUM
Number of study hours	30	10.0	35.0	75

Subject objectives

The aim of the course is to present selected transport processes using a mathematical description, particularly employing methods from discrete mathematics and graph theory. The modeling will focus on maritime transport, with special attention to issues related to ship trajectories and their dependence on dynamically changing hydrometeorological conditions.

During the course, students will explore tools that enable the analysis and optimization of routes in the context of real-world constraints and environmental parameters. The course will utilize a wide range of software tools based on the Python programming language, facilitating simulations, visualizations, and route optimization in maritime transport.

Learning outcomes

Course outcome	Subject outcome	Method of verification
[K7_U02] formulates and tests hypotheses concerning problems od transport systems and processes, as well as simple research problems	Is able to interpret modeling and optimization results in the context of real operational conditions.	[SU1] Assessment of task fulfilment [SU2] Assessment of ability to analyse information [SU5] Assessment of ability to present the results of task
[K7_W01] explains and describes, based on general knowledge in the field of scientific disciplines forming the theoretical foundations of Transport and Logistics, the construction and principles of operation of transport systems, processes and their components, as well as methods and means of their integration	Demonstrates a well-structured and theoretically grounded knowledge of key topics in Transport and Logistics, enabling the modeling and analysis of transport systems and processes.	[SW2] Assessment of knowledge contained in presentation
[K7_U01] utilizes acquired methods, tools and mathematical models for analysis and evaluation of transport systems and processes	Applies the Python programming language to implement route optimization algorithms in maritime transport. Understands fundamental methods for modeling transport processes using discrete mathematics and graph theory.	[SU1] Assessment of task fulfilment
[K7_W02] demonstrates structured and theory supported knowledge encompassing key issues in the field of Transport and Logistics, enabling modeling and analysis of transport systems and processes	Has knowledge of tools and data analysis techniques used in maritime transport.	[SW2] Assessment of knowledge contained in presentation

Subject contents

Course content – lecture

1. Introduction to Programming in Python

- Introduction to the Anaconda environment and basic data analysis tools
- Summary of Python programming fundamentals: data types, operators, control structures, functions
- Basic Python libraries used in transport analysis (NumPy, Pandas, Matplotlib)

2. Mathematical Methods in Transport Modeling

- **Graph models in transport** transport networks, nodes, and edges
- **Grid and discretization of the maritime environment**
  - The concept of a grid in maritime transport modeling
  - Discretization of the maritime environment description and representation in Python
  - Various grid representation methods: rectangular grids, hexagonal grids, irregular grids
- **Navigation-related concepts**
  - Geographical coordinates: latitude and longitude
  - Measurement units in navigation: nautical mile, knot
  - Representation of geographical coordinates in route modeling in Python
- **Shortest paths in transport models**
  - Route computation algorithms: Dijkstras, Bellman-Ford, A*
  - Flow problems in transport networks

3. Ship Trajectory Modeling in Maritime Transport

- Characteristics of ship movement and the impact of hydrometeorological conditions
- Trajectory prediction methods and their applications
- Optimization of shipping routes considering variable environmental conditions

4. Data Modeling and Analysis in Maritime Transport

- Application of data analysis in transport historical AIS data analysis
- Processing hydrometeorological data and its impact on ship trajectories
- Use of GIS systems in maritime transport analysis

Let me know if you need any modifications!

<table>
<tr><td>Prerequisites and co-requisites</td><td>

- **Mathematics** fundamentals of algebra, discrete mathematics, graph theory, and optimization methods.
- **Programming** basic proficiency in Python, including data structures, loops, functions, and fundamental libraries for data analysis (e.g., NumPy, Pandas).
- **Basics of Transport and Logistics** general understanding of transport systems, including maritime transport.

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<tr><td>Assessment methods and criteria</td><td>
<table>
<tr><th>Subject passing criteria</th><th>Passing threshold</th><th>Percentage of the final grade</th></tr>
<tr><td>Project</td><td>50.0%</td><td>100.0%</td></tr>
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<tr><td>Recommended reading</td><td>
<table>
<tr><td>Basic literature</td><td>

- **McKinney, W. *Python for Data Analysis* (O'Reilly, 2017)**
  - Processing transport data using Pandas and NumPy.
- **IMO (International Maritime Organization) *E-navigation Strategy Implementation Plan* (IMO, 2014)**
  - E-navigation strategies and maritime route optimization.
- **Dijkstra, E. W. *A Discipline of Programming* (Prentice Hall, 1976)**
  - A classical approach to graph algorithms, including the shortest path algorithm.

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<tr><td>Supplementary literature</td><td>any e-course for Python</td></tr>
<tr><td>eResources addresses</td><td></td></tr>
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<tr><td>Example issues/ example questions/ tasks being completed</td><td>For a given area, retrieve data describing marine conditions related to wave height and direction. Then, create an algorithm that avoids waves higher than 6 meters.</td></tr>
<tr><td>Practical activites within the subject</td><td>Not applicable</td></tr>
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