UNDERGRADUATE STUDY:

TRANSPORT, ITS AND LOGISTICS

SEMESTER (V)

Syllabus

Academic year 2024/2025

Course:	**Transport Optimization**				
Head of course: Prof. **Tonči Carić**, Ph.D.					
Co-lecturers: **Tomislav Erdelić**, Ph.D.					
Semester: **W**	Course code: **60608**	Lectures: **30**	Auditory exercises: **15**	Laboratory exercises: **0**	ECTS credits: **5**
Group for lectures: **30 - 40 students**			Group for auditory and laboratory exercises: **30 - 40 students**		

Objective of the course:

- Introduction to the basics of optimization with special reference to the application of the graph theory, use of heuristics, exact and approximation approaches to on the various transportation problems. In the general terms, a student should know how to describe the optimization problem, to define the model and determine the most appropriate optimization technique.

Learning outcomes:

After the completion of the course the students will be able to:

1. Define the concept of optimization in real traffic environment, linear and integer programming
2. Enumerate the stages of solving transportation problems and apply the matrix in assigning transport network
3. Distinguish between deterministic and nondeterministic computation
4. Distinguish between heuristic, exact and approximation methods approaches
5. Mathematically define optimization problems
6. Connect the real transportation problems with one of the main groups or other NP-hard optimization problems

LECTURES and EXERCISES

Week	Syllabus	Form of classes	Performed by	Lessons	Remark
1.	▪ Basic concepts of the graph theory	L	Tonči Carić	2	
	▪ Examples: ○ Graphs (directed, undirected, completed, uncompleted, ...) ○ Transport networks matrices	AE	Tomislav Erdelić	1	
2.	▪ Euler graphs, Hamiltonian path and Travelling salesman problem	L	Tonči Carić	2	
	▪ An example of Travelling salesman problem model	AE	Tomislav Erdelić	1	
3.	▪ Improvement of the transport activity by using combinatorial optimization in real traffic environment	L	Tonči Carić	2	
	▪ An example of solving traveling salesman problem for the real-world transport network, TSP algorithm development	AE	Tomislav Erdelić	1	
4.	▪ Mathematical model of the Vehicle routing problem, complexity of the problem estimation and various models in practice	L	Tonči Carić	2	
	▪ Vehicle routing problem ○ Models ○ Solving methodology ○ Development of an algorithm for initial solution	AE	Tomislav Erdelić	1	
5.	▪ Heuristically solving NP-hard problems with examples for vehicle routing problems	L	Tonči Carić	2	

	• Development of a heuristic algorithm for vehicle routing problem	AE	Tomislav Erdelić	1	
6.	▪ Prerequisites, achievable goals and computer applications development for the optimizations in the L transportation area (the results of projects with specific outcomes)	L	Tonči Carić	2	
	▪ Applications for transport optimizations in practice	AE	Tomislav Erdelić	1	
7.	▪ Location-allocation problems (Multi-source Weber problem), clustering problems	L	Tonči Carić	2	
	▪ Clustering problems ○ Models ○ Solving methodology ○ Development of k-means algorithm	AE	Tomislav Erdelić	1	
8.	▪ Bin packing problem	L	Tonči Carić	2	
	▪ Packing problems ○ Models ○ Solving methodology ○ Development of algorithm for initial solution ▪ Example: Strip packing problem	AE	Tomislav Erdelić	1	
9.	▪ Linear integer program and optimization process	L	Tonči Carić	2	
	▪ Problems with the relaxation of CLP and Simplex method solutions	AE	Tomislav Erdelić	1	
10.	▪ Methods for solving CLP ○ exact algorithms ○ approximation algorithms ○ heuristic algorithms	L	Tonči Carić	2	

	• Examples of exact, approximation and heuristic algorithms	AE	Tomislav Erdelić	1	
11.	▪ NP-hard and NP-complete problems	L	Tonči Carić	2	
	▪ Relation between practical problems and NP-hard and –complete mathematical problems	AE	Tomislav Erdelić	1	
12.	▪ Exact methods ○ Backtracking, branch and bound	L	Tonči Carić	2	
	• Example of branch and bound algorithm	AE	Tomislav Erdelić	1	
13.	▪ Heuristics methods ○ Greedy heuristic ○ Local search ○ Simulated annealing	L	Tonči Carić	2	
	• Algorithm development for vehicle routing problem	AE	Tomislav Erdelić	1	
14.	▪ Scheduling problems	L	Tonči Carić	2	
	• Scheduling problems ○ Models ○ Solving methodology ○ Development of algorithm for initial solution • Example: runway scheduling	AE	Tomislav Erdelić	1	
15.	▪ Systematization of the material ▪ Signatures	L	Tonči Carić	2	
	▪ Repetition and preparation for examination	AE	Tomislav Erdelić	1	

L = Lectures; **AE** = Auditory Exercises; **LE** = Laboratory Exercises; S = Seminars

STUDENT OBLIGATIONS AND EXAMS

Course completion signature:

At least 60% of lectures and exercises attendance.

Written exam: During the semester students have the option of taking the two tests (colloquiums). To pass final exam (both written and oral) it is necessary to correctly answer more than 60% of questions on both tests.

Oral exam: Student are required to pass a written exam (correctly answering at least 50% of all questions) to participate in oral exam.

LITERATURE

a) Obligatory literature:

1. Carić, T.: Authorized lecture presentation slides (internet, Merlin)
2. Fosin, J.: Authorized exercise presentation slides (internet, Merlin)
3. Pašagić, H.: Mathematical Methods in Transportation (in Croatian), Faculty of Transport and Traffic Sciences, Zagreb, 2003.

b) Recommended literature:

1. Toth, P., Vigo, D.: Vehicle Routing Problem, , SIAM Publishing, monographs on discrete mathematics and applications, Philadelphia, 2002
2. Hoos, H.H., Stuetzle, T.: Stohastic Local Search, Morgan Kaufman, 2005.

METHODOLOGY OF THE IMPLEMENTATION OF THE COURSE PLAN

1. LECTURES

Combination of blackboard teaching methods for theoretical part and individual student consultation is used.

2. AUDITORIAL EXERCISES

After the demonstration of the practical tutorial, each student has to solve individual exercises. Teaching assistant helps students and evaluates the student work.

3. DOCUMENTATION

The student's attendance at lectures, exercises and test records are kept during the semester. The documentation is published on the Internet (Merlin, and ISVU).

4. SCORING SYSTEM

Table 1 The scoring system for the monitoring of students and explained credit values in ECTS credits

no	Segment:	Required credits to be achieved:		Remark:	ECTS credits
		Min.	Max.		
1.	Presence in lectures:	9	15	Presence ≥ 60%	**1**
2.	Presence in exercises:	9	15	Presence ≥ 60%	**1**
4.	Colloquies (written 2x per semester) or written exam:	120	200		**2**
5.	Oral exam	60	100		**1**
Σ	Overall points	**Σ 198**	**Σ 330**	Overall ETCS points*:*	**Σ 5**

Table 2 - Explanation of the credit values in evaluations

CREDITS: % of points	Estimate based on attendance, seminar paper and two colloquies (or written exam) - [4 ECTS]:	The final score [5 ECTS]:
90 - 100	Excellent (5)	The final score after oral exam
80 - 90	Very good (4)	
70 - 80	Good (3)	
60 - 70	Sufficient (2)	