250ST2131 - Optimization Models of Transport Networks

Coordinating unit: 240 - ETSEIB - Barcelona School of Industrial Engineering
Teaching unit: 715 - EIO - Department of Statistics and Operations Research
Academic year: 2017
Degree: MASTER'S DEGREE IN INDUSTRIAL ENGINEERING (Syllabus 2014). (Teaching unit Optional)
MASTER'S DEGREE IN SUPPLY CHAINS, TRANSPORT AND MOBILITY (Syllabus 2014). (Teaching unit Optional)
MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 5
Teaching languages: English

Teaching staff
Coordinator: Codina Sancho, Esteve

Opening hours
Timetable: To be defined at the beginning of the semester

Prior skills
Prior knowledge of real analysis and algebra.
Using programming languages * oriented computing * Technical / scientific (* MATLAB and / or * Python) or equivalent.
Basic knowledge of Operational Research

Degree competences to which the subject contributes

Specific:
CETM3. Knowledge for planning, management and operation of transportation systems and mobility, ability to analyze service levels to users, operating costs and environmental and social such as mass transit, and private vehicle traffic impacts, air transport, sea transport, intermodal transport and urban mobility.
CESE4. Know and apply the techniques of modeling, simulation and optimization to solve the problems involved the design and management of supply chains.
CETM2. Understanding and quantifying capacity fundamentals transport systems and mobility determine the safety, quality and sustainability of transport infrastructure and optimizing the operation of these systems.

Teaching methodology
The teaching method will combine classic exhibition content sessions (theory) and laboratory sessions / problems to reinforce / complement the theory sessions. The teaching method requires specific training materials by monitoring the subject and conducting practice sessions. The theoretical sessions concerning paragraphs 1 and 2 of the agenda will be mostly with the help of slides, while concerning paragraphs 3,4,5 preferably incorporate the use of slate. Throughout the course you will be presenting and following one or more case studies to illustrate the application in practice of the cone of the course taken.

Learning objectives of the subject
Know the main equilibrium models used in planning and design of passenger transportation systems (road networks and public transport) and its relationship with the optimization problems in networks and optimization algorithms that are used in practice. Know the main elements and principles of modeling to create instances of the previous models. Perform iterations manually and with the aid of suitable software of algorithms: a) Frank-Wolfe, b) Spiess. Integration, use and
role of the previous models in the planning tools of passenger transport.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group: 0h 0.00%</th>
<th>Hours medium group: 30h 24.00%</th>
<th>Hours small group: 15h 12.00%</th>
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</thead>
<tbody>
<tr>
<td>Guided activities: 0h 0.00%</td>
<td>Self study: 80h 64.00%</td>
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Content

Non-linear Optimization Basics

Description:

Related activities:
Delivery of an exercise in problem solving for nonlinear flows on networks with an analysis of the solution. Verification of 1storder conditions.

Specific objectives:
- Solve small linear optimization problems using AMPL.
- Apply manually shortest path algorithms on small networks.
- State the conditions of Karush-Kuhn and Tucker for a nonlinear problem and check whether the solution verifies them or not.
- Perform steps of the gradient method manually.
- Perform a line search.

Traffic Network Models. Wardrop Equilibrium

Description:

Related activities:
- Exercise: calculate equilibrium flows in networks of small size

Specific objectives:
- Know the elements of network traffic modeling used in transportation planning and equilibrium models.
- Perform iterations with the algorithm of Frank-Wolfe and MSA.
- Meet the convergence criteria of the Frank-Wolfe algorithm
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<table>
<thead>
<tr>
<th>Models for public transportation networks</th>
<th>Learning time: 29h 10m</th>
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</thead>
<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 7h</td>
</tr>
<tr>
<td>Modeling elements: lines, segments, stops and transfers. Models based on times tables based on frequency systems. PathFinder model. Concept of strategy and the choice of lines by travelers. Connection with the principle of Wardrop equilibrium. Spiess and Florian's model. Congestion in public transportation systems. Queueing models at stops. Effective frequency. Use of the MSA method. Description of professional software packages incorporating PT models.</td>
<td>Practical classes: 3h 30m</td>
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<tr>
<td><strong>Related activities:</strong></td>
<td>Self study : 18h 40m</td>
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<tr>
<td>Solving an assignment problem in a non-congested network. Use of the method Spiess method.</td>
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<tr>
<td><strong>Specific objectives:</strong></td>
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<tr>
<td>Perform an all-or-nothing assignment following full PathFinder model.</td>
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<tr>
<td>Solving instances by hand of Spiess' assignment model of passenger to lines.</td>
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<tr>
<td>Application of the MSA method for the case of congested networks.</td>
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<tr>
<th>Extensions</th>
<th>Learning time: 41h 40m</th>
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<tbody>
<tr>
<td><strong>Description:</strong></td>
<td>Theory classes: 10h</td>
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<tr>
<td><strong>Related activities:</strong></td>
<td>Self study : 26h 40m</td>
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<tr>
<td>Exercise in laboratory class and delivery of a report</td>
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<tr>
<td><strong>Specific objectives:</strong></td>
<td></td>
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<tr>
<td>Solving by hand a small network combined model for assignment /modal choice.</td>
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<tr>
<td>Run STOCH simplified algorithm.</td>
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<tr>
<td>Meet and build traffic network models with interactions (asymmetric).</td>
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<tr>
<td>Use the method of diagonalization in test cases.</td>
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## Qualification system

40% Laboratory exercises + 45% Final Exam + 15% Discussion of a Case Study
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Regulations for carrying out activities

A compendium of formulae in two sheets (maximum) and a pocket calculator.

Bibliography

Basic:


Complementary:


Others resources:

Computer material

Plataforma ATENEA
  Resource

Sistema AMPL Estudiant
  Resource