250ST2031 - Routes of Vehicles

General Objective
Vehicle routing problems have numerous applications in the field of transportation, distribution and urban freight logistics, among others. This course introduces the main elements for the design of vehicle routes with particular emphasis on the following aspects:

- Different types of problems that arise in the area, depending on the type of application, service time constraints, constraints in the form of service, etc.
- Potential applications of vehicle routing problem.
- Models and formulations suitable to represent the problems.
- Some solution methods for obtaining solutions.

Specific Objectives
- To understand the main node routing problems (the traveling salesman problem and the vehicle routing problem) and the possible extensions to consider time windows, specific service modes, etc. To know the potential applications of node routing problems.
- To understand the main routes arc routing problems, and in particular, the Chinese postman problem and the rural postman problem. To know the potential applications of arc routing problems.
- To know possible modeling alternatives for different vehicle routing problems, and the possibilities and limitations of each of them.
- To know some basic solution methods for the studied problems.

Teaching methodology
The course is based on the attendance and active participation in class. The teaching method combines lectures with classes oriented to problem solving and case studies using available software. This methodology requires the study of specific course material and its application to different vehicle routing problems in the field of transportation, logistics and industry. Throughout the course case studies will be introduced and used to illustrate practical applications of the topic of the course. Each student will propose a potential vehicle routing problem and possible modeling alternatives and solution techniques. These models and techniques must be implemented and evaluated computationally.

Learning objectives of the subject

Coordinator: Elena Fernández Aréizaga

Teaching staff

Coordinator: Elena Fernández Aréizaga
### Study load

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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Learning time</th>
<th>Description</th>
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</table>
| **Introduction to vehicle routing problems.**                       | **5h**       | - Theory classes: 2h  
- Practical classes: 1h  
- Self study : 2h |
| **Models and formulations for vehicle routing problems.**           | **18h**      | - Alternatives for modeling connected solutions.  
- Subtour elimination constraints.  
- Miller- Tucker- Zemlin Inequalities.  
- Network flow type models. |
| **The Traveling Salesman Problem**                                  | **27h**      | - Theory classes: 6h  
- Practical classes: 3h  
- Self study : 18h |
| **The Capacitated Vehicle Routing Problem-CVRP**                    | **18h**      | - Alternatives for modeling capacity constraints.  
- Extension of Miller-Tucker-Zemlin inequalities.  
- Solution methods.  
- Lower bounds: relaxations and valid inequalities.  
- Upper bounds: heuristic methods. |
Implementation and delivery in due date of a series of personalized exercises proposed in class. (20 % final grade)
- Presentation and discussion in class of the problem proposed by the student, its modeling and solution alternatives, as well as the results of the computational experiments. (30 % final grade)
- Implementation and delivery in due date of a comprehensive report containing: (i) a description of the problem proposed and its potential applications; (ii) the considered modeling alternatives; (iii) the design and implementation details of the considered algorithms; and (iv) a description of the computational study of the implemented model and methods, performed on a set of instances, including analysis of the results and conclusions. (40 % final grade)
- Active participation in class (10% of final grade).

**Qualification system**

**Additional considerations for Vehicle Routing Problems**

<table>
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<tr>
<th>Learning time: 18h</th>
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<tbody>
<tr>
<td>Theory classes: 4h</td>
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<td>Practical classes: 2h</td>
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<tr>
<td>Self study: 12h</td>
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**Description:**
Problems with time window constraints. Problems with constraints on the type of service: pickup-and-delivery.

**Arc Routing Problems**

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<th>Learning time: 27h</th>
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<tbody>
<tr>
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<tr>
<td>Practical classes: 3h</td>
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<tr>
<td>Self study: 18h</td>
</tr>
</tbody>
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**Description:**
The Chinese Postman Problem, the Rural postman problem, the Capacitated Arc Routing Problem. Modelling the parity at the nodes. Solution methods: valid inequalities and heuristics.

**Other related problems**

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<th>Learning time: 12h</th>
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<tbody>
<tr>
<td>Theory classes: 4h</td>
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<tr>
<td>Practical classes: 2h</td>
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<tr>
<td>Self study: 6h</td>
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**Description:**

**Qualification system**

Implementation and delivery in due date of a series of personalized exercises proposed in class. (20 % final grade)
- Presentation and discussion in class of the problem proposed by the student, its modeling and solution alternatives, as well as the results of the computational experiments. (30 % final grade)
- Implementation and delivery in due date of a comprehensive report containing: (i) a description of the problem proposed and its potential applications; (ii) the considered modeling alternatives; (iii) the design and implementation details of the considered algorithms; and (iv) a description of the computational study of the implemented model and methods, performed on a set of instances, including analysis of the results and conclusions. (40 % final grade)
- Active participation in class (10% of final grade).
Bibliography

Basic:


Complementary:


Others resources:

Audiovisual material

Atenea