



## DECISION ANALYTICS

### Assignment 1: Constraint Programming

#### DUE DATE

This assignment should be submitted to Canvas before 11:59pm on **Friday 8/11/2019**.

Please submit a single ZIP file with your student number and name in the filename. Your submission should contain:

- A detailed documentation of all code you developed, including the tests and evaluations you carried out
- All Python code you developed in a single .py file that can be executed and that generates the outputs you are referring to in your evaluation

You can achieve a total of 50 points as indicated in the tasks.

#### TASK 1 (logic puzzle, 28 points)

In this task you will develop a constraint satisfaction model that solves the following logical puzzle:

*Carol, Elisa, Oliver and Lucas are going to university.  
One of them is going to London.  
Exactly one boy and one girl chose a university in a  
city with the same initial of their names.  
A boy is from Australia, the other studies Architecture.  
A girl goes to Cambridge, the other studies Medicine.  
Oliver studies Law or is from USA. He is not from South Africa.  
The student from Canada is either a historian or will go to Oxford.  
The student from South Africa is going to Edinburgh or will study Law.*

*What is the nationality of the history student?*

- A. Identify the objects for the constraint satisfaction model [1 point].
- B. Identify the attributes for the constraint satisfaction model [1 point].
- C. Identify the predicates for the constraint satisfaction model [1 point].
- D. Define the set of variables you need for modelling the puzzle as SAT problem [3 points].
- E. Define the explicit constraints contained in the sentences of the puzzle using first order logic [6 points].
- F. Define the implicit constraints required for solving the puzzle using first order logic [3 points].
- G. Create a CP-SAT model in Python and add all variables to the model [3 points].
- H. Add all explicit constraints to the CP-SAT model [6 points].
- I. Add all implicit constraints to the CP-SAT model [3 points].
- J. Solve the CP-SAT model and answer the question about the nationality of the history student [1 points].

## TASK 2 (project planning, 22 points)

In this task you will develop a constrained optimisation model to help decide on selecting the optimal combination of projects to take on.

The following table outlines 10 potential projects for a company to take on. Each project has an investment cost associated with it and a projected value. Further to that, certain projects are incompatible with other projects (e.g. if project 1 is taken on, project 4 cannot). Also, there are projects that can only be taken on together with other projects (e.g. project 3 requires projects 1 and 2 to be taken on as well).

Project	Requires	Incompatible	Value (k€)	Cost (k€)
1			18	12
2			51	43
3	1,2		32	12
4		1	80	76
5	3,4		65	42
6			44	43
7		1,2	91	87
8	3,6		65	43
9	3,5		92	65
10		4	69	62

The company's line of credit allows for a maximum budget of 400k€ to be spend on projects altogether.

What projects should be selected to maximise profit (i.e. value-cost) while not exceeding the budget?

- A. Define the set of variables you need for modelling this constrained optimisation problem [1 point].
- B. Define the constraints to model the incompatibilities between projects [3 points].
- C. Define the constraints to model the prerequisites of projects [4 points].
- D. Define the constraint to model the overall budget restriction [1 point].
- E. Define the maximisation criterion for the problem [1 point].
- F. Create a CP-SAT model in Python and add all variables to the model [1 point].
- G. Add all project incompatibility constraints to the CP-SAT model [3].
- H. Add all prerequisite constraints to the CP-SAT model [4 points].
- I. Add the budget constraint to the CP-SAT model [1 point]
- J. Add the maximisation constraint to the CP-SAT model [1 point]
- K. Solve the CP-SAT model and answer the question which projects to select [1 point].  
Also calculate the investment required and the profit generated [1 point].