University of Bergen
INF 170: Modeling and Optimization (Fall 2019)

Mandatory Assignment
(Option B)
Deadline: 21/10/2019 23:59

Submit your project through mitt.uib. Provide all your files and reports compressed in a single folder (.zip or .rar) named by your own full name. The folder should include two parts: 1. The main PDF file (named by your full name) including all your mathematical formulations, explanation, results and the written report required in each part. 2. AMPL folder (model code, data, running commands, solution file, etc.) named by your full name. you need to provide your AMPL codes separately for each question (one folder for each questions named by Question 1, 2 or 3). Include all files needed to run all parts of the project.(we need all files to be able to run without modifying your submission).

Question 1) (30 points)
Sudoku is one of the most popular puzzle games of all time. The goal of Sudoku is to fill a 9×9 grid with numbers so that each row, column and 3 ×3 section contain all of the digits between 1 and 9.
The following is claimed to be the world's hardest Sudoku! Use it as a sample input date. Write an AMPL model to solve this problem.
The solution of this sample Sudoku should be reported in the main PDF file and the model and the data file should be attached in the required format as follows:

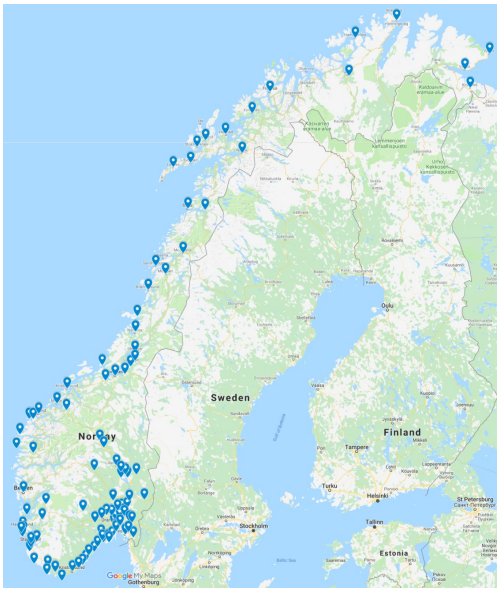
- `"Sudoku-YourName".mod`
- `"Sudoku-YourName".dat`

8								
		3	6					
	7			9		2		
	5				7			
				4	5	7		
			1				3	
		1					6	8
		8	5				1	
	9					4		

Question 2) (30 points)
What is shortest way of visiting 103 cities in Norway and then returning to the starting city? (Solve the TSP problem!)

- Use the input file "NorwayTSP Data.txt" which gives you the Xcoord and Ycoord of 103 cities in Norway.
- Use Gurobi solver and for MTZ and Svestka model use tightening constraints and also use Gurobi solver.

Use this option: `option gurobi_options "timelim=3600 outlev=1";` This option limits the running time to 3600 seconds. It stops searching after one hours and reports the best found solution. If it finds the optimal solution before one hour it tells you the running time.

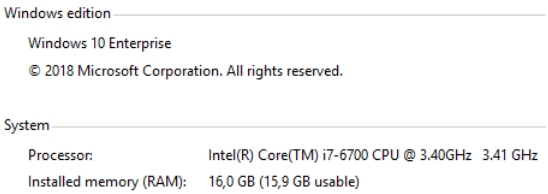


For this question, you need to report these:

1. On the main report (PDF file):
   - Report the following table: (for running time, if it stopped after 3600 seconds without finding the optimal solution just write 3600 under the running time)

Model Name	Number of variables	Number of constraints	Objective value	Running time
MTZ model Gain (Svestka) Steps (Dantzig)				

   - Plot the optimal solution or the best found solution (out of the three solution you get from each model). You can use any software for plotting. Note that AMPL is not a good option for plotting!
   - Specify your system information. For example:



2. Attachments:
   - `"TSP-log-YourName".txt report all you see on the AMPL screen (the running log)`
   - `"TSP-model-YourName".mod attach the AMPL model`
   - `"TSP-solutions-name of the model-YourName".txt`

Question 3) (40 points)
Four cargo vessels will be used for shipping oil from five available ports (labeled 1, 2, 3, 4, 5) to the main refinery during each day. There is no difference in the quality of crude oil in each ports, therefore the refinery can prepare it's daily required amount of oil from each of the available ports. The total daily crude consumption at the refinery is 750,000 barrels. Any vessel can be used for making any required shipments with their relevant fixed cost as follows.

Vessel	Fixed cost($)
I	120000
II	115000
III	125000
IV	100000

However, because of differences in the vessels and ports capacities, the total amount of on-board quantity on each vessel as well as the total amount of loaded quantity at each ports is restricted.
In addition to the cost of loading operation per barrel at each available ports (as shown in the following table), there is a fixed cost associated with using each port as $20000 for port 1 and 2 and $30000 for port 3, 4 and 5 .

loading cost per barrel (in $)					
	Vessels				
port	I	II	III	IV	Available product at port
1	5	7	6	5	200000
2	4	3	4	2	120000
3	5	4	5	4	260000
4	7	9	7	6	180000
5	3	2	3	1	110000
vessel capacity	390000	330000	250000	270000	

Note that for each cargo vessels, it is not required to go full and each of them can be used once per day. furthermore they can visit at most up to two ports in their daily shipments.

A: The objective is to find the best possible loading plan to minimize the total cost of preparing daily crud oil for the refinery from different available ports. (20 points)

B: Now instead of having the loading costs based on the vessels, we have different loading tariffs for each port based on the amount of loaded quantity. In the following table you can find the relevant tariffs for each port base on the amount of loaded quantity. Tariffs are the same for all vessels. Considering the previous constraints and also the present predefined tariffs, Find the minimum cost of delivering daily crude oil in to the market. (20 points)

loading cost per barrel (in $)			
	Quantity		
Port	$0 \leq Q \leq 99999$	$100000 \leq Q \leq 179999$	$Q \geq 180000$
1	6	5	4
2	5	4	3
3	6	4	2
4	7	5	5
5	3	3	1

Formulate a mathematical model for part A and B to determine daily loading plan from available ports such that the refinery minimizes cost. Implement the model in AMPL and solve it. What is the optimal loading plan and how much cost it provides?
The mathematical model and the final results should be reported in the main PDF file. Provide all your AMPL files (model code, data, running commands, solution file, etc.) compressed in a single file with following format:

- `"Refineryplan-model-YourName".mod`
- `"Refineryplan-data-YourName".dat`
- `"Refineryplan-run-YourName".run`
- `"Refineryplan-solution-YourName".txt`