Assignment-1

Data-Driven Decision-Making
MGT7180

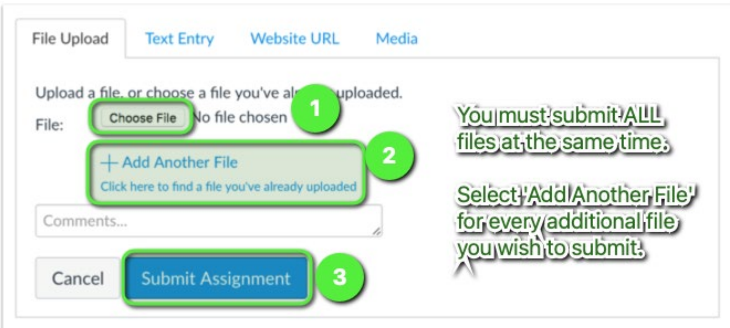
2020-2021

<u>Deadline: Friday, March 19, 2021, 23:59, CANVAS</u>

The following four problems comprise assignment-1, which is an ***individual*** assignment. Use mathematical programming models and techniques to solve these problems. For each problem, besides formulating the model, clearly explain why each part, e.g., expression, inequality/equation, condition, etc, is being included or used in the model for that problem (to what information in the problem setting it corresponds). Also, include any intermediate calculation you perform to formulate the model, e.g., unit conversion.
Use appropriate mathematical typesetting, e.g., the <u>MS-Word Equation</u> editor, for presenting your models and equations. When solving the model, use succinct comments in your R-code: one or at most two lines each, relating the important parts of the code to their corresponding parts in the mathematical model. Include the R-code and the R output text (solution) in the assignment report paper right after the model formulation of the problem. At the end of each solution, explicitly state the decision in terms of the variables and the objective.
Also, upload the functional R-code files (i.e., they run without any errors and generate the same results as those which you report in your paper) to the "dummy assignment" on Canvas for each problem that you solve. Use recognizable filenames: e.g., "problem-2.R". **Note that you must upload all three (or four if you split the file of problem 1) <u>R files to the dummy assignment at the same time</u> (see the figure below). Your assignment paper must be uploaded to the main assignment (not the dummy assignment).** The assignment on Canvas that has the text of the four problems is the Main assignment for uploading your assignment paper.

K = kilo = 10^3
M = million = 10^6
B = billion = 10^9

(**B**≠ $\mathbb{B}$)



NB: Please carefully read the important administrative information at the end (on the last page) of this assignment.

1) Supermarket Shelf Space **[30 marks]**

Jumbo supermarket sells its own brand of peanut butter among other brands, where the profit per jar is € 0.35 for its own brand and € 0.25 for all other brands. The shelf space allocated to peanut butter is 0.5 m^2, and each jar of any brand of peanut butter takes 50 cm^2.

a) The daily sales records indicate that the number of jars sold of their own brand never exceeds half as many jars of the other brands combined. **The supermarket's operations manager wants to know how many jars of their own brand and how many jars of other brands combined to stock each day on the allocated shelf space for maximum profit.**

b) Sales records have also shown that when their own brand is on discount, it sells at least 1.2 times as many jars as other brands combined. However, the profit of their own brand drops to € 0.20 when on discount and that of the other brands is unchanged. **How many jars of their own brand and how many jars of other brands combined should be placed in the allocated shelf space when their own brand is on discount?**

2) Fleet Planning [25 marks]

NederVerzend is planning to buy ships from a British shipbuilder in three traveling range categories, long, medium, and short, where the price of a unit ship is £ 70 M, £ 55 M, £ 40 M, respectively. The spending limit for buying these ships is £ 2 B. Shipment orders are expected to be more than enough to fully utilize any number of ships (that they would purchase within their budget) in each category. The annual net profit is calculated after subtracting the ship's purchase price. From utilizing one ship, the net profit is £ 4.2 M, £ 3.1 M, £ 2.6 M, respectively. The company has foreseen the hiring of enough personnel to manage 40 ships. However, the overall facilities capacity is equivalent to 60 short-rang ships, where a medium-range ship is equivalent to 1.5 short-range ship, and a long-range ship is equivalent to 2 short-range ships.

The CEO of NederVerzend wants to know how many of each category to purchase for maximum total profit, and the amount of that total profit.

3) Production and Distribution [35 marks]

Ontgifter is a company that produces a special detoxifying supplement. Although they can produce the supplement at eight plants, because of limited resources, they have to choose only some of the plants in any given month to maximize profit. Operating any of the plants incurs a fixed cost of € 70 K for each month the supplement is produced there. Each plant can produce at most 120 kg of the supplement per month at a cost of € 10 per kilogram. The shipment cost of the packaged end product to customers is € 0.01 per kilogram per kilometer. The pairwise distances among the eight cities where all eight plants and eight customers are located are given in Table 1. Each city has one plant and one customer (wholesaler active in that city). However, the customer is not necessarily coupled to the plant of its city, i.e., it is not necessary to choose both in the planned solution. But if a plant ships to the customer in the same city, their distance is assumed to be zero. The order amount of the customers for the month being planned in this problem and what they are willing to pay are given in Table 2. Ontgifter can decide to fill each of the eight orders or not. However, if a customer's order is filled, it must be by only one plant. Orders cannot be partially filled: an order is either fully delivered to the customer or the customer's offer is declined.

The chief operating officer (COO) wants to know which plants should produce the supplement in that month and for which customers.

Table 1. City Distances (km)

City	A	B	C	D	E	F	G	H
A	0	976	1808	1984	3029	1532	206	2657
B	976	0	1198	1043	2105	1383	833	1722
C	1808	1198	0	794	1418	1325	1597	1020
D	1984	1043	794	0	1167	2058	1773	829
E	3029	2105	1418	1167	0	2750	2818	391
F	1532	1383	1325	2058	2750	0	1251	2352
G	206	833	1597	1773	2818	1251	0	2435
H	2657	1722	1020	829	391	2352	2435	0

Table 2. Purchase Orders

Customer	Order Amount (kg)	Bid Price (€)
A	68	75,840
B	41	44,470
C	37	46,420
D	54	87,880
E	33	43,950
F	39	21,100
G	58	74,950
H	51	84,080

4) Question! [10 marks]

When the objective function involves an absolute value of a variable, but all constraints are linear, how can the problem be reformulated as a linear program: without the absolute value function? Consider the following small problem as an example to answer the question:

$$\begin{aligned} \min \quad & 3|x_1| + x_2 \\ \text{s.t.} \quad & x_1 + 3x_2 \geq 7 \\ & x_1, x_2 \geq 0 \end{aligned}$$

This assignment assesses the understanding and ability to use mixed integer linear programming models. The assignment must be submitted via CANVAS by 11:59 pm on Friday, 19th March 2021. **Students must ensure their name and student ID is included on the title page of their individual assignment.**

Please note that the School has a number of policies governing the submission of student work. For all elements of assessment associated with this course, you must be familiar with the School's policies on:

- Participation, Preparation for Classes and Private Study;
- Preparation and Submission of Assessed Work; and
- Plagiarism, Collusion and Fabrication.

These policies are detailed in the Queen's Management School Postgraduate Student Handbook.

The individual assignment will be marked using the postgraduate conceptual marking scale as recommended by the University (please refer to the Queen's Management School Postgraduate Student Handbook for further information).

The following criteria are also considered when assessing the assignment:

- Demonstration of wide reading and understanding of the assignment task
- Ability to synthesise and critically evaluate relevant material
- Quality and relevance of evidence/example presented to support position/claims
- Structure including planning, organizing, flow and coherence
- Overall presentation