Assignment-1

Data-Driven Decision-Making

D^{3}M

MGT
7180

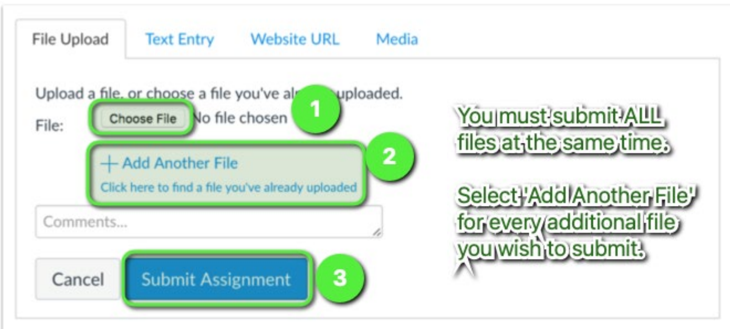
2022-2023, 2nd semester

Deadline: Friday, March 24, 2023, 23:59, CANVAS

The following three problems comprise assignment-1, which is an ***individual*** assignment with 50% of the overall module mark. 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 proper mathematical typesetting, e.g., the MS-Word Equation 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 (error-free) 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., "YourName-YourLastName-problem-2.R". **Note that you must upload all three R files to the dummy Canvas Assignment at the same time (see the figure below). Your assignment paper must be uploaded to the main Canvas Assignment (not the dummy Canvas Assignment).** The Assignment on Canvas that has the text of the three problems (this pdf) is the main Assignment for uploading your assignment-1 paper.



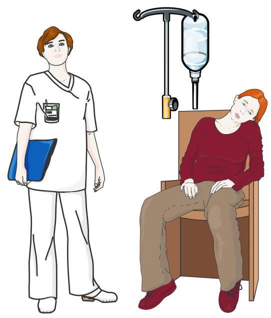
NB: Please carefully read the important administrative information at the end (on the last page) of this assignment-pdf.

Using mathematical typesetting (MS-Word Equation), inclusion of the code and R-output next to the model components in your paper, and the functionality (being error-free) of the files uploaded to Canvas are part of the assessment for all three tasks (problems 1, 2, and 3, below), and the lack thereof affects the mark awarded to the tasks.

1) Nurse Planning [35 marks]

The infusion center at UMC Hospital provides (drug) administration services for various treatments, including cancer chemotherapy, immunotherapy, rheumatoid treatments, ferrotherapy, and blood transfusion. To ensure a reliable patient flow throughout the day, i.e., short waiting time for patients and little overtime for nurses, the center requires at least the following number of nurses to be scheduled to work at the center throughout the week:

Mon	Tue	Wed	Thu	Fri	Sat	Sun
17	13	15	19	14	16	11



If a full-time nurse is employed, she is required to work five consecutive days followed by two days off. A part-time nurse is required to work three consecutive days followed by four days off. The cost of employing full-time and part-time nurses depends on the day of the week:

	Full-time	Part-time
Weekdays	€ 250 / day	€ 150 / day
Saturdays	€ 315 / day	€ 185 / day
Sundays	€ 375 / day	€ 225 / day

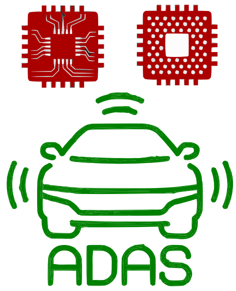
The pay difference is because full-time nurses are specialized with extensive trainings and with permanent contracts (more costs), whereas part-time nurses are general nurses (e.g., not specialized in chemotherapy) with temporary contracts. However, according to labor regulations, at most 25% of the time can be covered by part-time employment.

Formulate and solve a mathematical program (MILP) to answer the following questions:

1. How many full-time and how many part-time nurses should the infusion center have on its payroll to minimize the total nursing cost, while meeting all requirements?

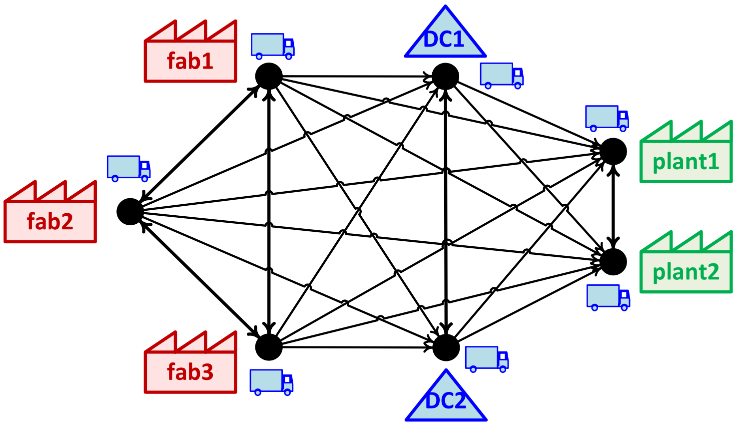
2. How much is the minimum total cost per week?

2) Chipset Logistics **[35 marks]**



DXP is a manufacturer of various types of semiconductor chips, including telecom, automotive, and healthcare. The automotive business unit of the company is releasing their state-of-the-art advanced driver-assistance system chipset developed in the 3-nm CMOS technology. Besides producing at their own fab (fab1), they have outsourced the chipset production to two pure-play foundries (fab2 and fab3). The chipsets can be shipped to two plants of a car manufacturing customer (plant1 and plant2) either directly from the fabs or through two distribution centers (DC1 and DC2). The chipsets can move among fabs, between DCs, between plants, and from fabs (through DCs) to plants.

The three fabs can produce at most 400K, 600K, and 200K packs of chipset, respectively (K=1000). The two plants demand exactly 400K and 180K packs of chipsets, respectively. The cost of shipment via each possible link is indicated in the table below. Note that due to administrative or economic reasons, the cost of bidirectional links are asymmetric. Because of reliability measures, at most 400K packs of chipset can be sent via any shipment link.



Per pack cost of shipment via the links (in €).

from \ to	fab1	fab2	fab3	DC1	DC2	plant1	plant2
fab1		100	60	100	100	400	400
fab2	180		180	20	20	160	300
fab3	8	160		20	10	200	240
DC1					24	40	240
DC2				16		40	240
plant1							20
plant2						140	

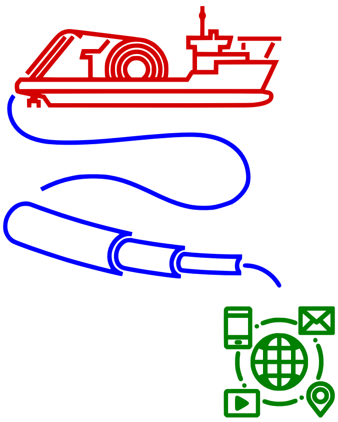
Formulate and solve a mathematical program (MILP) to answer the following questions:

1. How many chipset packs should be sent via each link (and in which direction if applicable) to minimize the total shipment cost, while fulfilling demand of both plants?

2. How much is the minimum total shipment cost?

3) Ocean Internet Cables **[30 marks]**

DG-Lynx is a manufacturer of "ocean Internet cables" [1] (submarine communication cables). For the production plan of the next quarter, the company is considering two types of cable. The manufacturing department is required to produce the following amounts by the end of each month of the plan (demand table below):



Demanded cable lengths (in kilometers).

Date	Type-A	Type-B
Jan 31	8,000	2,000
Feb 28	16,000	10,000
Mar 31	6,000	10,000
Total	30,000	22,000

Plant availability (hours).

Date	Plant-1	Plant-2
Jan	1,400	3,000
Feb	600	800
Mar	2,000	600

Note that the entire demand must be fulfilled, and the cables are shipped to customers at the end of the month based on the above demand table. The excess production of the month enters inventory at the end of that month. That is, during the month while the cables are being produced, no inventory cost incurs.

Two plants can be allocated for the production of these orders. The number of hours available and the time it takes to produce one kilometer of each type of cable are given in the plant availability table above and the production rate table below, respectively:

Plant production rates (hours per kilometer).

Date	Plant-1	Plant-2
Type-A	0.30	0.32
Type-B	0.24	0.28

The costs involved in the plan are as follows (ƻ is a fictitious currency used in this problem):

- A kilometer of either cable costs ƻ 10.00 per hour to produce at either plant.
- There is a holding (inventory) cost of ƻ 0.20 per kilometer of either cable per month.
- The raw material cost is ƻ 6.20 per kilometer of Type-A and ƻ 7.80 per kilometer of Type-B.
- The packing cost is ƻ 0.46 per kilometer of either type.

The selling price is ƻ 14.00 per kilometer of Type-A and ƻ 18.00 per kilometer of Type-B.

Formulate and solve a mathematical program (MILP) to answer the following questions:

1. Devise a production schedule for the maximum possible total profit (revenue minus costs), while meeting all requirements.
2. How much is the total profit under the optimal production schedule you have devised?

Hint: There should be no inventory at the end of March, i.e., the demanded lengths of each month must be fulfilled by the end of each month, and the production in January and February may carry over inventory to the next month (on top of fulfilling the demand of the month).

[1] Because of the very long distance to satellite orbits (35,000 km above Earth), which notably delays the transmission and reception of signals (data), over 95% of the global Internet traffic goes through oceans (https://www.submarinecablemap.com). One of the longest such submarine links (2Africa) is 45,000 km, ranging from the UK to India, while surrounding Africa. It connects several countries on its path. Not only are satellite distances too long, but they also have to be traversed twice for each transmission (or reception)—once to the satellite from the origin and once from the satellite to the destination—making it effectively twice as long (70,000 km).

Note:

This assignment assesses the understanding and ability to use mixed integer linear programming (MILP) models. The assignment must be submitted via Canvas by 11:59 pm on Friday, March 24th, 2023. **Students must ensure their name and student ID are included on the title page of their individual assignment papers uploaded to Canvas.**

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 assignment will be marked using a combination of the mark scheme and the postgraduate conceptual marking scale as recommended by the University.

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