

# Optimisation for Transportation Systems

## M.Sc. Transportation, SS 24

### Problem Set 1

---

**Due Date** : 17/06/2024, 23:00 (11 pm)

**Grading** : 30% of your final grade

---

#### Introduction

This is the first problem set for the Optimization in Transport course of the Transportation Systems M.Sc. It consists of 2 problems, and it is weighted as 30 % of your final grade. (Note: the remaining 30% and 40% are assigned later to the second and third problem sets, respectively.) Your answers should be uploaded on Moodle before 17/06/2024, 23:00 (11 pm).

#### Problem 1: Formulation (60 points)

Formulate the optimization models (objective function and constraints) for the following problem description:

To produce one bicycle (among 8 different types: type A, type B, ..., and type H), the working hours needed by the personnel and required steel mass can be different. Moreover, fixed monthly renting costs of equipment needed for the bicycle production can vary. Detailed values are given in Table 1 below, together with the financial profit of selling one bicycle (per each type). Also, the maximum available resources per month are specified.

Table 1.

Bicycle type	Working hours [hr]	Steel mass [kg]	Equipment rental costs [\$ / month]	Selling profit [\$]
A	20.5	14.5	1000	45
B	13.5	22.0	1200	100
C	15.0	13.0	2000	65
D	16.5	8.0	1400	80
E	24.0	16.5	2500	120
F	32.0	9.5	2100	95
G	25.5	21.0	1800	70
H	19.0	18.5	1100	30
Monthly maximum resources	200	770	3500	-

To maximise the total revenue, please formulate an optimization model that determines the optimal total number of bicycles and the optimal types, which should be produced per month as follows:

**(a)** Formulate the general problem, including decision variables, the objective function and constraints (10 points).

**(b)** Now, please model and solve the problem under following conditions:

**b.1.** Maximum 3 types of bicycles can be produced only, while types C and E must be produced in any conditions (10 points).

**b.2.** Among renting budget and steel mass constraints, maximum one constraint should be satisfied (10 points).

**b.3.** If bicycles of type F are produced, then bicycles of type A and G must be produced, and the type B must not be produced (10 points).

**b.4.** If bicycles of types A and H are produced, then bicycles of type C can be produced with 20% shorter working hours, while selling profit of bicycles type H can be 20% higher (10 points).

**b.5.** If bicycles of types B and G are produced, then minimum one of the types C and F should be produced, however, total personnel requirements should not exceed 180 hours then (10 points).

## Problem 2: Simple data analysis in Pandas (40 points)

Conduct simple exploratory data analysis on passenger entry and exit data from London Underground system, **using the Pandas package in Python**.

Please use as input one of the *StationFootfall\_YYYY.csv* files from the following webpage: <http://crowding.data.tfl.gov.uk/> (where yyyy stands for year between 2019 and 2022). Import the input file as Pandas Dataframe and perform the following tasks:

- a. Find the total number of entering passengers on Saturdays and Sundays between February and May within that year (10 points).
- b. Find 5 stations with the highest total number of exiting passengers between July and December and plot these results with a bar chart (10 points).
- c. Calculate the 20% and 80% percentile rates for the total annual station volumes of exiting passengers (i.e. among the annual sums of all the individual stations) (10 points).
- d. Visualise the daily entering and exiting passenger flows for a given station in a 3-month period from August to October (10 points).