Four-step model — April 02, 2025

Question 1: Gravity model

We are trying to establish an origin-destination matrix for trips during the peak hour among Lausanne, Fribourg, Yverdon and Vevey. The total number of trips generated and attracted by each city has been established, as reported in Table 1. The analysts assume that the number of trips between a pair (r, s) of cities is given by a gravity model:

$$f_{rs} \approx \alpha_r O_r \beta_s D_s e^{-\gamma d_{rs}},$$

where α_r, β_s and γ are unknown parameters, O_r is the number of trips generated by city r, D_s is the number of trips attracted by city s, and d_{rs} is the distance (in km) between r and s, as reported in Table 2.
Describe the procedure to establish the origin-destination matrix. **Optional:** If you have access to a computer, calculate the matrix.

City	Out	In
Lausanne	1600	2500
Fribourg	1700	1800
Yverdon	2100	1400
Vevey	800	500

Table 1: Trips generated and attracted by each city

Origin	Destination	Distance
Lausanne	Fribourg	72
Lausanne	Yverdon	37
Lausanne	Vevey	20
Fribourg	Yverdon	53
Fribourg	Vevey	58
Yverdon	Vevey	59

Table 2: Distance between cities

Question 2: All-or-nothing

We are interested in the traffic that travels across four cities in Switzerland: Lausanne, Fribourg, Vevey, and Yverdon. The road network linking these cities is represented by the network in Figure 1, where the number reported on a link is the travel time in minutes necessary to traverse the link. The travel time for the link between the same two nodes in the other direction is associated with the exact same travel time.
The travel demand is represented by the origin-destination matrix reported in Table 3 on the next page. If we assume that every trip is performed along the fastest path between its origin and destination, what is the flow of traffic on each link of the network?

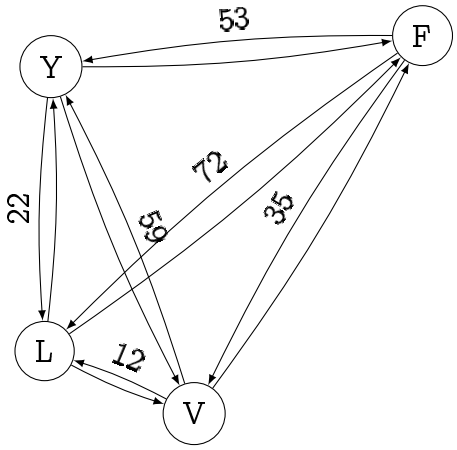

Figure 1: Network with travel time (minutes)

Origin	Destination	Number of trips
Lausanne	Fribourg	649.3
Lausanne	Yverdon	639.2
Lausanne	Vevey	311.6
Fribourg	Lausanne	841.1
Fribourg	Yverdon	714.9
Fribourg	Vevey	144.0
Yverdon	Lausanne	1103.1
Yverdon	Fribourg	952.4
Yverdon	Vevey	44.5
Vevey	Lausanne	555.7
Vevey	Fribourg	198.3
Vevey	Yverdon	46

Table 3: Origin-destination matrix