Assumptions

Each course requires exactly 2 teaching hours per week.

Sets and Variables

Let $I_1, I_2, I_3, \ldots$ denote families of programs/years. If two courses belong to the same set I_k, then they are part of the same 1-year program or the same year of a longer program. Let

$$I_k = A_k \cup B_k,$$

where:

- A_k is the set of compulsory courses,
- B_k is the set of optional courses.

$$x_{i,t} = \begin{cases} 1, & \text{if course } i \text{ is scheduled at time slot } t, \\ 0, & \text{otherwise.} \end{cases}$$

where $t \in \{1, 2, \ldots, 45\}$ corresponding to 9 available time slots per day (9am–6pm) over 5 weekdays.

Core constraints

No overlapping compulsory courses within the same program/year

$$\sum_{i \in A_k} x_{i,t} \leq 1 \quad \forall k, \ \forall t \quad (1)$$

Each course needs exactly 2 hours per week (constraint subject to change)

$$\sum_{t=1}^{45} x_{i,t} = 2 \quad \forall i \quad (2)$$

Optional courses cannot run concurrently with compulsory ones

$$x_{i,t} + x_{j,t} \leq 1 \quad \forall i \in A_k, \ \forall j \in B_k, \ \forall t \quad (3)$$

y_k are integer variables that will be minimized in order to reduce overlaps as much as possible

$$\sum_{i \in I_k} x_{i,t} \leq y_k \quad \forall k, \ \forall t \quad (4)$$

Constraints for Questions

No teaching after 5pm (9–6pm restriction)

$$x_{i,9} = x_{i,18} = x_{i,27} = x_{i,36} = x_{i,45} = 0 \quad \forall i$$

No teaching on Friday after 2pm

$$x_{i,40} = x_{i,41} = x_{i,42} = x_{i,43} = x_{i,44} = x_{i,45} = 0 \quad \forall i$$

Core teaching being delivered without clashes (not including workshops for now)

$$\sum_{i \in I_k} x_{i,t} \leq 1 \quad \forall t, k$$

Potential Lunch break (12–2pm)

$$\sum_{i \in I_k} (x_{i,4} + x_{i,5}) - 1 \leq b_1$$

$$\sum_{i \in I_k} (x_{i,13} + x_{i,14}) - 1 \leq b_2$$

$$\sum_{i \in I_k} (x_{i,22} + x_{i,23}) - 1 \leq b_3$$

$$\sum_{i \in I_k} (x_{i,31} + x_{i,32}) - 1 \leq b_4$$

$$\sum_{i \in I_k} (x_{i,40} + x_{i,41}) - 1 \leq b_5$$

$$b_1, b_2, b_3, b_4, b_5 \geq 0$$

Other optional constraints

Consecutive 2 hour lectures

$$x_{i,t} \leq x_{i,t+1} + x_{i,t-1}$$

$$\forall i, \forall\ t \in \{2, \ldots, 8\} \cup \{11, \ldots, 17\} \cup \{20, \ldots, 26\} \cup \{29, \ldots, 35\} \cup \{38, \ldots, 44\}$$

Daily teaching load being less than 6 hours

$$\sum_{t=1}^{9} \sum_{i \in I_k} x_{i,t} \leq 6 \quad \forall k$$

$$\sum_{t=10}^{18} \sum_{i \in I_k} x_{i,t} \leq 6 \quad \forall k$$

$$\sum_{t=19}^{27} \sum_{i \in I_k} x_{i,t} \leq 6 \quad \forall k$$

$$\sum_{t=28}^{36} \sum_{i \in I_k} x_{i,t} \leq 6 \quad \forall k$$

$$\sum_{t=37}^{45} \sum_{i \in I_k} x_{i,t} \leq 6 \quad \forall k$$

Objective function (minimize overlaps and penalties)

$$\min \sum_{k} y_k + W \sum_{r=1}^{5} b_r$$

where W is a potential weight (optional)