

Constraints formulated as maths equations

- Our university has:
 - A given **r** number of rooms. Each room might be a **special room**.
 - **Special rooms** are rooms with specific furnitures. For instance lab furnitures are in **lab** rooms. **Lab** rooms are considered as a **special room**.
 - Rooms that aren't **special rooms** are referred too as **rooms**.
 - **Amphitheatres** are considered as **special rooms**.
 - Let r be the number of rooms, $r_{special}$ the number of special rooms. We must ensure that:

$$r \in \mathbb{N}$$
$$r_{special} \leq r$$

- A given **t** amount of teachers. Each teacher has one or more corresponding subjects he/she can teach.
 - Let t be the number of teachers.

$$t \in \mathbb{N}$$

- **N** promotions (= year the student is on).
 - Let $N_{promotions}$ be the number of promotions:

$$N_{promotions} \in \mathbb{N}$$

- Each promotion has:
 - **n** classes (= group of students).
 - Let $n_{classes}$ be the number of classes:

$$n_{classes} \in \mathbb{N}$$

- To each class, we assign **s** subjects (= materials) the class has to attend.
 - Let s be the number of subjects.

$$s \in \mathbb{N}$$

- Each of the **s** subjects has:
 - A fixed number of hours **h** to be completed.

- Let h_s the number of hours that must be completed as part of this course and h_{s_a} the currently attributed hours for this subject.
- Let $t_{s_i}, \forall i \in \mathbb{N}$ be a timeslot attributed to subject s . h_{s_a} is defined as:

$$h_{s_a} = \sum_{i=0}^{h_s} t_{s_i}$$

- We must ensure:

$$h_{s_a} = h_s$$

- The **h** hours are divided in **online_hours** and **presential_hours**.
- We need to make sure that **online_hours** $\leq (30\%) * h$
 - Let h_{s_o} the number of online hours attributed to subject s and h_{s_p} the number of presential hours attributed to subject s . We must ensure:

$$h_{s_a} = h_{s_p} + h_{s_o}$$

$$h_{s_o} \leq 0.30 \times h_{s_a}$$

- To complete the **h** hours:

- One course duration is 1h30.
 - Let t_i be an assigned timeslot. We must ensure that:

$$\frac{\sum_{i=0} t_i}{1.5} = k, k \in \mathbb{N}$$

- A class can attend as many **courses** as required to attend the **h** hours.
 - Reminder : h_s is the number of hours that must be completed as part of a course. Thus:

$$h_s \in \mathbb{R}^+$$

- Some **courses** need to take place in special rooms depending on the **course's** format. (For example practical works need to be in labs)
 - Let r_i denote a specific room and s denote a course.
 - Define $R_{special}$ as the set of all special rooms, and $S_{special}$ as the set of all courses requiring special rooms.
 - For each course $s \in S_{special}, \exists r_i \in R_{special}$ such that:

$$s := r_i \implies r_i \in R_{special}$$

- Two different classes can't attend the same **course** in the same **room** on the same **timeslot**
 - Let $T(r_i)$ be the set of timeslots assigned to room r_i and let $S(t_i, r_i)$ be the set of courses assigned to room r_i on timeslot t_i :

$$\forall t_i \in T(r_i), |S(t_i, r_i)| \leq 1$$

- An exception is made for **courses** taking place in **amphitheatres**
 - Let A be the set of all amphitheatres.
 - Let $T(r_i \in A)$ be the set of timeslots assigned to room r_i , r_i being an amphitheatre.
 - Let $S(t_i, r_i)$ be the set of courses assigned to room r_i on timeslot t_i .

$$\forall t_i \in T(r_i \in A), |S(t_i, r_i)| < +\infty$$

- One class can't have two **courses** in the same **timeslot**
 - Let $T(c_k)$ be the set of timeslots assigned to class c_k .
 - Let $S(t_i, c_l)$ be the set of courses assigned to class c_k on timeslot t_i .

$$t_i \in T(c_k), |S(t_i, r_i)| \leq 1$$

- The **courses** can take place in defined **timeslots** each day.
 - **Timeslots** are defined as follows:
 - 08:15 to 09:45
 - 10:00 to 11:30
 - 11:45 to 13:15
 - 13:30 to 15:00
 - 15:15 to 16:45
 - 17:00 to 18:30
 - 18:45 to 20:15
 - No **course** can be scheduled on saturday and thursday afternoon (from 13:30 to 20:15). No **course** can be scheduled on Sunday.
 - Let T_{sunday} be the set of timeslots on sunday.
 - Let $T_{thursdayafternoon}$ be the set of timeslots on thursday afternoon (from 13:30 to 20:15).
 - Let $T_{saturdayafternoon}$ be the set of timeslots on saturday afternoon (from 13:30 to 20:15).
 - We define $T_{restricted}$ as $T_{restricted} = \{T_{sunday}, T_{thursdayafternoon}, T_{saturdayafternoon}\}$
 - Let T be the set of all timeslots.

$$\forall t_i \in T, t_i \notin T_{restricted}$$

- Students must have at least one free slot a day. Either 11:45 to 13:15 or 13:30 to 15:00. This is to ensure they can eat.
 - Let $T_{lunch} = \{(11 : 45, 13 : 15), (13 : 30, 15 : 00)\}$
 - Let $T(c_k)$ be the set of timeslots assigned to class c_k .

$$\forall t_i \in T(c_k) : \exists t_i \in T_{lunch}, t_i \notin T(c_k)$$

- **Courses** can be either **online** or **presential**. Respecting the previous condition regarding total amount of online hours.

- Certain **courses** may require specific time slots due to logistical reasons. (e.g. lab courses requiring 3h sessions, thus, two back-to-back **timeslots**)
 - Let $T_{adjacent} = \{(t_i, t_{i+1})\}$:
 - Let $T(s)$ be the set of timeslots assigned to course s .
 - If s requires 3 hours:

$$\forall (t_i, t_{i+1}) \in T(s) : (t_i, t_{i+1}) \in T_{adjacent}$$

- To take place, each **course** needs:
 - An available room. (= A room where there is no course taking place)
 - A corresponding **class**
 - A **teacher** that can teach the **course's** subject.
 - The **teacher** must be available. He can't give two courses at the same time.
 - Let $T(t_j)$ be the set of timeslots assigned to teacher t_j .
 - Let $S(t_i, c_k)$ be the set of courses assigned to class c_k on timeslot t_i .

$$t_i \in T(t_j), |S(t_i, t_j)| \leq 1$$

- The **teacher** may have preferred teaching time or days. The **schedule** should try to accommodate these preferences as much as possible.
 - Let $P(t_j)$ be the set of preferred timeslots for teacher t_j .
 - Let $T(t_j)$ be the set of timeslots assigned to teacher t_j .
 - Given $\forall t_i \in T(t_j)$, minimize:

$$C_{preference} = \sum_{t_i \notin P(t_j)} 1$$

- Room and Resource Allocation:
 - Scheduling must allocate regular or special rooms (e.g., labs or amphitheaters) based on course requirements.
 - Ensure adequate use of room resources while preventing overbooking or misuse of special-purpose spaces.