# HEI Scheduling constraints problems

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## Notations

- $G$ denotes the set of all group $g$; $T$ denotes the set of all teacher, $C$ denotes the set of all course.
- All element of the set of all awarded courses $AC$ will be indexed. In other words :

$$ac_i \in AC, \ i \in \mathbb{N}$$

- Let $t_{ac_i}$ and $c_{ac_i}$ be the corresponding teacher and the corresponding course resp. to $ac_i$.
- Let $STC_{t,c} \subset AC$ be the set of all awarded course which has same teacher and course (Same Course and Teacher):

$$\forall\, i, j \in \mathbb{N} \,:\, (ac_i, ac_j \in STC_{t,c}) \Longleftrightarrow \big(t_{ac_i} = t_{ac_j} = t\big) \text{ and } \big(c_{ac_i} = c_{ac_j} = c\big)$$

- Let $STDC_t \subset AC$ be the set of all awarded course which has same teacher but different course (Same Teacher but Different Course) :

$$\forall\, i, j \in \mathbb{N} \,:\, (ac_i, ac_j \in STDC_t) \Longleftrightarrow \big(t_{ac_i} = t_{ac_j} = t\big) \text{ and } \big(c_{ac_i} \neq c_{ac_j}\big)$$

- Let $AC_g \subset AC$, the set of all awarded course related to a group $g$.

# About the Constraints

**Constraint 1** *A teacher can't teach two or more different groups at the same time for a same course if it is face-to-face session but can if it is a video conference session.*

Let $p_{d,STC_{t,c}} \in \{-1;1\}$,be a an indicator constant.

$$p_{d,STC_{t,c}} = \begin{cases} 1\ , & \text{if all } ac_i \text{ related to } STC_{t,c} \text{ are presentials at a given } d \text{ day} \\ -1\ , & \text{if all } ac_i \text{ related to } STC_{t,c} \text{ are online at a given } d \text{ day} \end{cases}$$

$\forall\ s \in S,\ \forall\ d \in D,\ \forall\ t \in T,\ \forall\ c \in C$ :

$$2p_{d,STC_{t,c}} \cdot \left( \sum_{r \in R} \left( \sum_{ac_i \in STC_{t,c}} o_{ac_i,d,r,s} \right) \right) \leq 3p_{STC_{t,c}} - 1 \tag{1}$$

***<u>Otherwise :</u>*** if $p_{d,STC_{t,c}}$ is the binary variable such as :

$$p_{d,STC_{t,c}} = \begin{cases} 1\ , & \text{if all } ac_i \text{ related to } STC_{t,c} \text{ are presential ata given } d \text{ day} \\ 0\ , & \text{if all } ac_i \text{ related to } STC_{t,c} \text{ are online at a given } d \text{ day} \end{cases}$$

which marks whether all awarded courses related to $STC_{t,c}$ are presentials or not.

Let $M \in \mathbb{N}^*$ be a majoration constant.

Therefore :

$$\sum_{r \in R} \left( \sum_{ac_i \in STC_{t,c}} o_{ac_i,d,r,s} \right) \leq 1 + M(1 - p_{STC_{t,c}}) \tag{2}$$

**Constraint 2** *A teacher cannot simultaneously teach two or more different courses.*

$\forall\ s \in S,\ \forall\ d \in D, \forall\ t \in T$ :

$$\sum_{r \in R} \left( \sum_{ac_i \in STDC_t} o_{ac_i,d,r,s} \right) \leq 1 \tag{3}$$

**Constraint 3** *A group cannot simultaneously have two or more different course sessions.*

$\forall\ g \in G,\ \forall\ s \in S,\ \forall\ d \in D:$

$$\sum_{r \in R} \left( \sum_{ac_i \in AC_g} o_{ac_i,d,r,s} \right) \leq 1 \tag{4}$$

**Constraint 4** *A group should have 2 hours of break per day.*

$\forall\ g \in G,\ \forall\ d \in D:$

$$\sum_{ac_i \in AC_g} \left( \sum_{r \in R} \sum_{s \in S} o_{ac_i,d,r,s} \right) \leq 3 \tag{5}$$

**Constraint 5** *Only one session per course in a day.*

$\forall\ ac_i \in AC,\ i \in I,\ \forall\ d \in D:$

$$\left( \sum_{r \in R} \sum_{s \in S} o_{ac_i,d,r,s} \right) \leq 1 \tag{6}$$

**Constraint 6** *Give one day without the same course after a session of this course.*

$\forall\ d \in D,\ \forall ac_i \in AC,\ i \in I:$

$$\left( \sum_{r \in R} \sum_{s \in S} o_{ac_i,d+1_d,r,s} \right) + \left( \sum_{r \in R} \sum_{s \in S} o_{ac_i,d,r,s} \right) \leq 1 \tag{7}$$

where $1_d$ is the unit of day.

**Constraint 7** *Suitable room for every course session.*

- Let $g_{ac_i}$ be the corresponding group to a $ac_i$.
- Let $s_{g_{ac_i}}$ be the group size of a group $g_{ac_i}$.
- Let $rc_r$ be the room capacity of a room $r$.

$\forall ac_i \in AC,\ i \in I, \forall\ r \in R,\ \forall\ s \in S, \forall\ d \in D$

$$o_{ac_i,d,r,s} rc_r \geq s_{g_{ac_i}} \tag{8}$$

**Constraint 8** *Finish the total hour of every course.*

Let $D(ac_i, d_q)$ be the total duration of a $ac_i$ within a time interval $[d_0, d_q] \subset D,\ d_0 \leq d_q$.

$\forall\ ac_i \in AC,\ i \in I :$

$$\sum_{d=d_0}^{d_q} \sum_{r \in R} \sum_{s \in S} o_{ac_i,d,r,s} = D(ac_i, d_q) \tag{9}$$