# Integer Programming Methods
# Homework set 5

**Please conform to the following instructions:**

1. Make the homework in groups of 2 or 3 persons.
2. Hand in you answers as py file.
   (a) Use the titles "`IntPM_Homework_Set_5_<groupname>.py`" and "`IntPM_Homework_Set_5_<groupname>.pdf`" for the code and a (short) report, respectively.
   (b) At the start of your file add a comment mentioning your names.
3. Hand in your report by e-mail to m.walter@utwente.nl.

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## Exercise 1

We consider a job shop scheduling problem with the following data:
**Input:**

- Number $m$ of machines `machines` $= \{1, 2, \dots, m\}$.
- List `jobs` of jobs.
- Processing times `processingTimes`$[k, j] \in \mathbb{Z}$ indicating the processing time of job $j$ on machine $k$.

The goal is to schedule each job $j \in$ `jobs` on every machine $m \in$ `machines` such that

- each machine can only run one job at a time,
- each started job runs until it is completed,
- a job on machine $m \geq 2$ can only start once it is completed on machine $m - 1$.
- among all such schedules, the overall makespan (i.e., time until all jobs on machine $m$ are completed) is minimized.

The task of this exercise is to create **two** implementations of MIP models that tackle this problem. These can be of completely different types, but they can also be a base model as well as the same model augmented with problem-specific cutting planes. Also price-and-branch methods (i.e., only price for the root LP) are allowed despite them being heuristic. It is recommended to use the Gurobi solver via Python for which you find an installation manual here. However, feel free to use any other solver software. Test instances are provided here.

The report shall be short and concise, containg a description of the implemented models and insights (potentially supported by *brief* computational results).