

# Documentation of optimization tool

1.	Optimization Software Instruction.....	2
2.	System Messages Instruction.....	3
3.	Command Line Basics .....	4
4.	Input Data Description.....	5
	4.1 Weights .....	5
	4.2 Timeslots_G.....	5
	4.3 Timeslots_UG.....	5
	4.4 Classrooms_G.....	6
	4.5 Classrooms_UG.....	6
	4.6 Sections .....	6
5.	Output Data Description .....	8
	5.1 Summary .....	8
	5.2 Undergrad Schedule.....	8
	5.2 Grad Schedule.....	9

# 1. Optimization Software Instruction

To use the optimization software, user should take the following steps:

1. **Open** a Command window (in Windows) or a Terminal (in mac).
2. **Install homebrew** (by pasting the following text into Terminal and pressing the *Enter* key)

```
/usr/bin/ruby -e "$(curl -fsSL https://raw.githubusercontent.com/Homebrew/install/master/install)"
```

3. **Install Python using homebrew** (by pasting the following text into Terminal and pressing the *Enter* key)

```
brew install python
```

4. **Navigate** in the command line to the directory containing *optimize.py* using *cd* *directoryName*. To simplify the work, please put the input file and the *optimize.py* file under the same directory.
5. **Run the tool** (by typing a line following the syntax below to Terminal and pressing the *Enter* key). If the command ran successfully, the output file will be found under the same directory as *optimize.py*.

```
python optimize.py "input.xlsx" (type in your input-data file name, wrapped by quotation mark)  
"output.xlsx" (type in the output file name you want, wrapped by quotation mark)  
weight1(optional) weight2(optional) weight3(optional)
```

- *input.xlsx* represents the name of the input file while *output.xlsx* represents the name of the output file.
- The last three values are the desired weight assigned to the three evaluation metrics: average classroom utilization rate, the number of professors who are allocated at least one back-to-back class, and the number of professors who have to work more than two days a week. The weights can be any decimal between 0 and 1, with 1 indicating the corresponding feature is very important and 0 as not important at all. If the end user didn't input any weights, then the software will by default interpret weight1 = 1, weight2 = 1 and weight3 = 0.2.
- For example, type in

```
python optimize.py '2019Spring.xlsx' '2019Schedule.xlsx' 0.3 1 0.3
```

if your input data is called "2019Spring.xlsx", and you want the output data to be called "2019Schedule.xlsx", and you want metric 1 and 3 to be weighted 0.3 times as important as metric 2.

## 2. System Messages Instruction

The software prints system messages to help the end user either track the optimization status or identify the error. Below are three examples:

1. If any of the input/output files does not exist, the software will notify the end user by printing *File "{FileName}" is not found* in the command line.
2. If any of the key input information is missing, such as input file or output file, then the software will notify the end user by printing *Correct syntax: python optimize.py inputFile outputFile weight1(optional) weight2(optional) weight3(optional)*
3. If the optimization successfully started, the software will update the end user with current progress and the time consumption of each part. For instance, after setting up the objective of the model, the tool will notify the end user by printing *Set Objective --> XX minutes elapsed*. When the optimization work is finished, the software will inform the end user by printing *Results in "{outputFile}"*. (As shown in Figure 1)

```
Preprocess Data Input
Data Preprocessing Finished --> 0.2 minutes elapsed
You input 533 classes, 107 undergraduate timeslots, 134 graduate timeslots, 30
undergraduate classrooms and 8 graduate classrooms
Optimization Starts
Set Variables --> 0.1 minutes elapsed
Set Objective --> 3.2 minutes elapsed
Set Constraint 1 --> 0.1 minutes elapsed
Set Constraint 2 --> 0.2 minutes elapsed
Set Constraint 3 --> 0.1 minutes elapsed
Set Constraint 4 --> 1.4 minutes elapsed
Set Constraint 5 --> 4.6 minutes elapsed
Set Constraint 6 --> 0.2 minutes elapsed
Optimize --> 28.0 minutes elapsed
Write Solution--> 0.2 minutes elapsed
Successfully Finished Optimization in 40.5 minutes
Results in "Sample.xlsx"
```

Figure 1: Sample of end user interaction

### 3. Command Line Basics

The following commands are commonly used in Terminal:

1. To obtain current directory (Windows):  
*cd*  
To obtain current directory (Mac):  
*pwd*
2. To change directory:  
*cd directoryName*
3. To change drive (Windows):  
*D:\*
4. To move up one level:  
*cd ..*
5. To creating new directory:  
*mkdir directoryName*
6. To list content of current directory (Windows):  
*dir*  
To listing content of current directory (Mac):  
*ls*

## 4. Input Data Description

### 4.1 Weights

The weights assigned on three evaluation metrics. The weight is between 0 and 1, while 1 means the feature is very important and 0 represents totally indifferent. By default, the three weights are 1, 1, 0.2 respectively.

**weight1:** The weight assigned to average classroom utilization rate. The higher the weight, the more the tool would try to increase the value of this metric.

**weight2:** The weight assigned to the number of professors who have to work more than two days a week. This metric is set as a punishment to the overall scheduling performance, thus the higher the weight, the more the tool would try to decrease the value of this metric.

**weight3:** The weight assigned to the number of professors who are allocated at least one back-to-back. The higher the weight, the more the tool would try to increase the value of this metric.

### 4.2 Timeslots\_G

Sheet Name: **Timeslots\_G**

A sheet contains the timeslots information for graduate level courses.

Column 1: **No**

A single integer representing the timeslot that would be assigned to graduate level courses.

Column 2: **Session**

Session status representing the length of the timeslot. Session column should only take one of the following values: “Full Semester”, “First Half”, and “Second Half”.

Column 3: **Day**

One or two alphabets representing the weekday information of the timeslot. Day column should take one of the following values: “M”, “T”, “W”, “H”, “F”, “MW”, and “TH”.

Column 4: **StartTime**

The column indicates the start time of the timeslot. Values in StartTime column should be in the format as “HH:MM AM/PM”, such as “9:00 AM” and “12:30 PM”.

Column 5: **EndTime**

The column indicates the end time of the timeslot. Values in EndTime column should be in the format as “HH:MM AM/PM”, such as “10:00 AM” and “6:30 PM”.

Column 6: **Timeslots**

The column indicates all of the information of the timeslot. Values in Timeslots column is the combination of column Day + column StartTime + column EndTime + column Session, such as “MW 8:00 - 9:30 AM (Full Semester)” and “W 12:30 - 3:30 PM (First Half)”.

### 4.3 Timeslots\_UG

Sheet Name: **Timeslots\_UG**

A sheet contains the timeslots information for undergrad level courses.

**Column 1: No**

A single integer representing the timeslot that would be assigned to undergrad level courses.

**Column 2: Session**

Session status representing the length of the timeslot. Session column should only take one of the following values: “Full Semester”, “First Half”, and “Second Half”.

**Column 3: Day**

One or two alphabets representing the weekday information of the timeslot. Day column should take one of the following values: “M”, “T”, “W”, “H”, “F”, “MW”, and “TH”.

**Column 4: StartTime**

The column indicates the start time of the timeslot. Values in StartTime column should be in the format as “HH:MM AM/PM”, such as “9:00 AM” and “12:30 PM”.

**Column 5: EndTime**

The column indicates the end time of the timeslot. Values in EndTime column should be in the format as “HH:MM AM/PM”, such as “10:00 AM” and “6:30 PM”.

**Column 6: Timeslots**

The column indicates all of the information of the timeslot. Values in Timeslots column is the combination of column Day + column StartTime + column EndTime + column Session, such as “MW 8:00 - 9:30 AM (Full Semester)” and “W 12:30 - 3:30 PM (First Half)”.

## **4.4 Classrooms\_G**

**Sheet Name: Classrooms\_G**

A sheet contains the classrooms information for graduate level courses.

**Column 1: Classrooms**

The column indicates the building and room name for a classroom that would be only assigned to graduate level courses. Values in Classrooms column should be in the format as “Building Name + Room Name”, such as “JKP102”.

**Column 2: Capacity**

An integer represents the capacity of the classroom.

## **4.5 Classrooms\_UG**

**Sheet Name: Classrooms\_UG**

A sheet contains the classrooms information for undergrad level courses.

**Column 1: Classrooms**

The column indicates the building and room name for a classroom that would be only assigned to undergrad level courses. Values in Classrooms column should be in the format as “Building Name + Room Name”, such as “ACC310”.

**Column 2: Capacity**

An integer represents the capacity of the classroom.

## **4.6 Sections**

**Sheet Name: Sections**

A sheet contains the class information for all graduate and undergraduate level courses to be allocated.

**Column 1: section**

A five figures integer representing the specific section index of a class. The same class can have multiple sections.

**Column 2: course**

A combination of department code and a three-figure integer representing a specific course offered by the department. Values in course column should be in the format as “XXX-number”, such as “ACCT-370” and “FBE-440”.

**Column 3: level**

One or two alphabets representing the level of the course, it’s either undergrad or graduate. level column should take one of the following values: “UG” or “G”.

**Column 4: units**

A number indicates the unit of a specific section and course. UG level course should normally be either 2 or 4 units while G level course should normally be either 1.5 or 3 units.

**Column 5: session**

A number indicates the session number of a specific section and course, where 0 = Full Semester, 1 = First Half and 2 = Second Half.

**Column 6: seats\_offered**

An integer indicating the seats number offered by a specific section and course.

**Column 7: first\_instructor**

The column indicates the first instructor who will be teaching the section and course. Values in first\_instructor column should be in the format as “Last name, middle name, first name”, such as “Lee, Mike” and “Jaconi, Kristen, Elizabeth”.

**Column 8: second\_instructor**

The column indicates the second instructor who will also be teaching the section and course. Values in second\_instructor column should be in the format as “Last name, middle name, first name”, such as “Lee, Mike” and “Jaconi, Kristen, Elizabeth”. If there’s no second instructor for a particular class, simply leave the cell as empty.

## 5. Output Data Description

### 5.1 Summary

Sheet Name: **Summary**

A sheet contains the summary of the objective values produced by the optimization model.

Column 1: **Variable**

The column with all the objective variable names.

Column 2: **Description**

A sentence or a formula describing the calculation logic and meaning of the variable.

Column 3: **Optimal Value**

The optimal value of the objective variable generated by the optimization model. They are metrics used to measure the performance of the optimization model.

### 5.2 Undergrad Schedule

Sheet Name: **Undergrad Schedule**

A sheet contains the suggested schedule and all the related information for undergrad level courses.

Column 1: **section**

A five figures integer representing a specific section that is being assigned.

Column 2: **Course**

A combination of department code and a three figures integer representing a specific course offered by the department.

Column 3: **Classroom**

A combination of building code and room number representing the assigned classroom for the section and course in previous column.

Column 4: **Time**

The column indicates the assigned timeslot for the section and course. It is in the same format as the one in Timeslots column in Timeslots sheet in the input data, and it contains information about weekday, start time, end time, and session.

Column 5: **Session**

Session column represents the session pre-assigned to the course. Session column is in one of the following values: "Full Semester", "First Half", and "Second Half".

Column 6: **Day**

The column represents the weekday which is being assigned to the course. Day column is in one of the following values: "M", "T", "W", "H", "F", "MW", and "TH".

Column 7: **StartTime**

The column indicates the assigned start time for the course. Values in StartTime column is in the format as "HH:MM AM/PM", such as "9:00 AM" and "12:30 PM".

Column 8: **EndTime**



The column indicates the assigned end time for the course. Values in EndTime column is in the format as “HH:MM AM/PM”, such as “9:00 AM” and “12:30 PM”.

**Column 9: units**

The unit information of the course.

**Column 10: Seats Offered**

The number of seats that would be offered by the course.

**Column 11: Classroom Capacity**

The capacity of the classroom assigned to the course.

**Column 12: Utilization Rate**

The utilization rate of the space in the classroom. It is calculated as (Seats Offered / Classroom Capacity) and is shown in %.

**Column 13: First Instructor**

The column indicates the first instructor who will be teaching the section and course.

**Column 14: Second Instructor**

The column indicates the second instructor who will also be teaching the section and course. If there's no second instructor, the cell is left as empty.

## 5.2 Grad Schedule

**Sheet Name: Grad Schedule**

A sheet contains the suggested schedule and all the related information for graduate level courses.

**Column 1: section**

A five figures integer representing a specific section that is being assigned.

**Column 2: Course**

A combination of department code and a three figures integer representing a specific course offered by the department.

**Column 3: Classroom**

A combination of building code and room number representing the assigned classroom for the section and course in previous column.

**Column 4: Time**

The column indicates the assigned timeslot for the section and course. It is in the same format as the one in Timeslots column in Timeslots sheet in the input data, and it contains information about weekday, start time, end time, and session.

**Column 5: Session**

Session column represents the session pre-assigned to the course. Session column is in one of the following values: “Full Semester”, “First Half”, and “Second Half”.

**Column 6: Day**

The column represents the weekday which is being assigned to the course. Day column is in one of the following values: “M”, “T”, “W”, “H”, “F”, “MW”, and “TH”.

**Column 7: StartTime**

The column indicates the assigned start time for the course. Values in StartTime column is in the format as “HH:MM AM/PM”, such as “9:00 AM” and “12:30 PM”.

**Column 8: EndTime**

The column indicates the assigned end time for the course. Values in EndTime column is in the format as “HH:MM AM/PM”, such as “9:00 AM” and “12:30 PM”.

**Column 9: units**

The unit information of the course.

**Column 10: Seats Offered**

The number of seats that would be offered by the course.

**Column 11: Classroom Capacity**

The capacity of the classroom assigned to the course.

**Column 12: Utilization Rate**

The utilization rate of the space in the classroom. It is calculated as (Seats Offered / Classroom Capacity) and is shown in %.

**Column 13: First Instructor**

The column indicates the first instructor who will be teaching the section and course.

**Column 14: Second Instructor**

The column indicates the second instructor who will also be teaching the section and course. If there's no second instructor, the cell is left as empty.