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**QUANTITATIVE MANAGEMENT MODELLING**

**FINAL EXAMINATION – OPTIMIZATION MODEL**

**A PROJECT REPORT**

***Submitted by***

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PROJECT REPORT

OPTIMIZATION MODEL

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**ABSTRACT**

The assignment aims to apply a systematic analysis of individual student attributes to inform the composition of groups, with the overarching objective of maximizing the potential for success in the collaborative project.

The objective of this assignment appears to be the strategic grouping of 15 students for a collaborative project based on various key factors. The assignment involves analyzing multiple variables such as meeting hours, experience, GPA, and other relevant criteria for each student. The ultimate goal is likely to form well-balanced groups that leverage the strengths and capabilities of individual members, with the aim of optimizing the overall performance and success of the group project.

**INTRODUCTION**

**Project Overview – Goal of the project**

The project aims to enhance success rates by employing a strategic approach to student group assignment. The core methodology involves utilizing integer linear programming to identify the optimal solution, thereby maximizing the project's overall success.

The assignment seems to utilize a data-driven approach, assigning weights or percentages to different criteria for each student, and then using this information to determine the optimal groupings. By identifying patterns and trends in the data, the objective is to create groups that are likely to work well together and contribute effectively to the success of the project.

we have been asked to assign 15 students to a group project.

Division: The 15 students has been put into five different groups which means each group has 3 students.

**Data and variables**

A typical analytics project starts with Data Preparation:

The data has been randomly selected and the key factors are the following:

\*Group Number\*

This column indicates the group numbers of the 15 different students. This particular column has not been taken in the further process as again there has been a random assignment of the groups.

\*Roll Number\*

Students have their respective roll numbers from 1-15.

\*GPA as percentage\*

The students have been scaled on a percentage from 0 to 100 where 0% being given to the student with least overall grade and 100% to students with the highest overall grade. As the clarity on the objectives & meeting hours are interlinked they should do well on the latter to improve their GPA.

\*Experience\*

The goal is to use this data to assign a rating to each student, indicating their level of relevance in terms of work experience. Collecting information on each student's work experience relevant to the project. This could include internships, part-time jobs, or coursework related to the project's focus. This limitation in skills can affect the team's ability to address various aspects of the project, potentially leading to challenges in implementation or problem-solving. The quality of work produced by team members with the least experience might be affected due to a lack of familiarity with industry standards, best practices, or project-specific requirements. Students with the most relevant work experience receive a rating of 100, while the students with little to no relevant work experience receive a rating of 0.

\*Attendance\*

We have Gathered attendance data to understand each student's commitment to the project. This includes attendance in project-related meetings, workshops, and discussions. Students who consistently attend project-related activities demonstrate a higher level of commitment and reliability. The meetings will be held to give the updates on progress, methodology used etc. If a student will not cater the hours required he/she might loose on the important information and might not be able to contribute his/her part to the project. The total number of meeting hours serves as a quantitative measure of a student's effort and involvement in the project. Here if a student consistently attends project-related activities receive a rating of 100 points. Students who do not attend or have low attendance receive a rating of 0 points.

**DATA GENERATION PROCESS**

1. Define Factors Influencing Success:

Identifying three factors that we believe influence the success of groups in the project. This includes Academic Performance (GPA), Experience, Attendance.

1. Decision Variables:

Defining the decision variables that represent the assignment of students to groups. For each student, creating binary variables (0 or 1) indicating whether they belong to a specific group.

1. Generate Random Data:

We have used R's randomization functions to generate data for the identified factors. In this case,

For GPA: Generating random GPA percentage values within a realistic range of 0 – 100%.

For Experience: Assigning random values representing the experience level of each student.

For another factor - Attendance: Randomly assigning the attendance percentage of each individual.

1. Record Collected Data:

Documenting the generated data for each student and factor. Creating a dataset that includes information on GPA, experience, attendance.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Student No. | Attendance | Experience | GPA Percentage | Weighted Avg |
| 1 | 8 | 18 | 17 | 14 |
| 2 | 11 | 70 | 81 | 54 |
| 3 | 17 | 57 | 38 | 37 |
| 4 | 27 | 17 | 33 | 26 |
| 5 | 6 | 94 | 60 | 53 |
| 6 | 27 | 94 | 60 | 60 |
| 7 | 28 | 13 | 12 | 18 |
| 8 | 20 | 83 | 29 | 44 |
| 9 | 19 | 47 | 58 | 41 |
| 10 | 2 | 55 | 63 | 40 |
| 11 | 6 | 55 | 51 | 37 |
| 12 | 5 | 24 | 51 | 27 |
| 13 | 21 | 76 | 53 | 50 |
| 14 | 12 | 18 | 56 | 29 |
| 15 | 23 | 41 | 87 | 50 |
| Mean | 15 | 51 | 50 |  |

**MODEL BUILDING**

In the context of the assignment, model building involves creating a mathematical optimization model that helps in forming groups to maximize the chance of success for each group on a class project. Let's break down the model building process into key components:

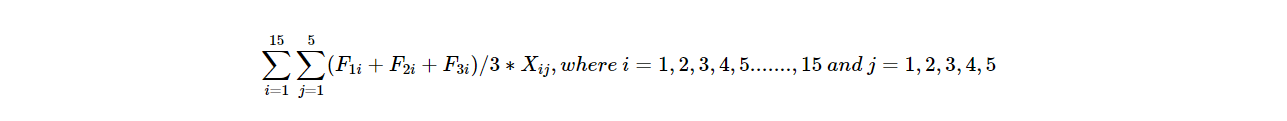
1. Decision variables:

Let Xij be a binary decision variable, where Xij =1 if student i is assigned to group j, and Xij = 0 otherwise.

Where, i is students ranging from 1 to 15 and j is groups ranging from 1 to 5.

1. Objective Function:

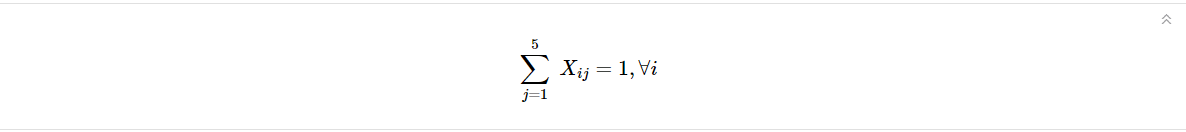
Maximize the overall chance of success for all groups. The objective function can be formulated based on the three factors identified (e.g., GPA, Experience, Attendance). Let's denote these factors as F1, F2 and F3.



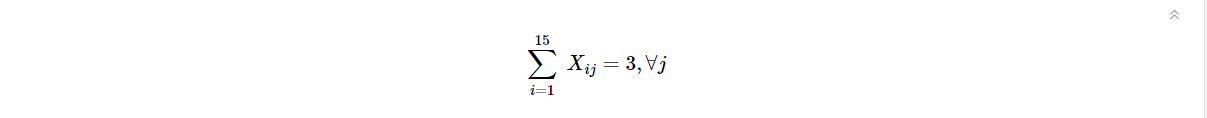
This objective function aims to maximize the weighted sum of factors for each student across all groups.

1. Constraints:

* Each student is assigned to exactly one group.



* Each group should have exactly 3 members.

****

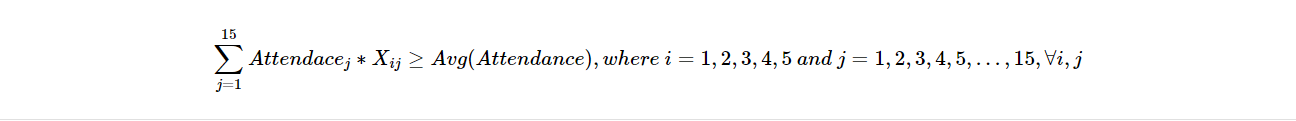
* Non-negativity constraints on decision variables:

Xij ≥ 0,∀i,j

These constraints ensure that each student is in one group, each group has three members, and the decision variables are binary.

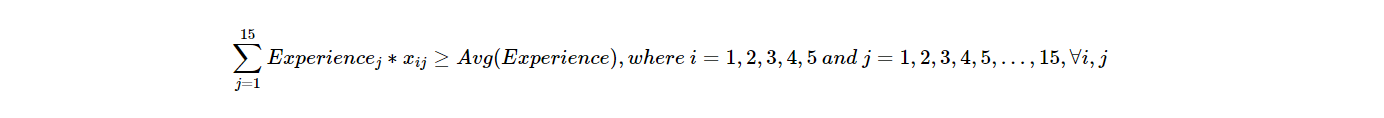
* Factor 1:

The total meeting hours are a numerical measure of a student's commitment to and engagement in the project.



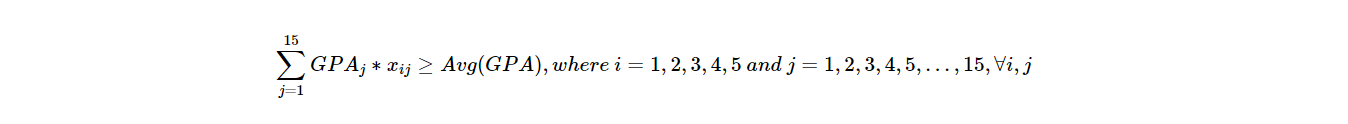
* Factor 2:

The objective in assessing Experience is to assign a rating to each student based on their relevance in terms of work experience related to the project.



* Factor 3:

The column depicting students' overall grades utilizes a percentage scale ranging from 0% to 100%.



**APPROACH TO SOLVE LP MODEL**

1. Select an Optimization Solver:

Choosing an appropriate optimization solver in R. We have included popular libraries such as lpSolve and ensuring that the chosen solver can handle binary variables and linear programming.

2. Define Decision Variables and Objective Function:

Using R to define the decision variables and formulating the objective function based on the identified factors that influence group success (i.e., GPA, Experience, Attendance). Expressing the objective function as a linear combination of these factors.

3. Formulate Constraints:

Translating the requirements into mathematical constraints. Ensuring that each student is assigned to exactly one group, each group has three members, and the decision variables are binary.

4.Implement the Model:

We have written the R code to implement the optimization model using the chosen solver. Utilizing functions provided by the solver to set up decision variables, objective function, and constraints.

5.Solve the Model:

Using the solver to find the optimal solution that maximizes the objective function. The solver will adjust the assignment of students to groups to achieve the best possible outcome.

6.Interpret the Results:

Retrieving and interpreting the results obtained from the solver and also Identifying which students are assigned to each group and analyzing the overall success score of each group based on the objective function.

7. Sensitivity Analysis:

Conducting sensitivity analysis to understand how changes in input data or constraints affect the solution. This step provides insights into the robustness of the solution.

**FINDINGS AND CONCLUSION**

**FINDINGS:**

We have examined the results of the analysis:

Assigning students to different groups based on the constraints.

Specifically:

Students 2, 6, and 15 are in Group 1.

Students 8, 9, and 13 are in Group 2.

Students 3, 4, and 5 are in Group 3.

Students 7, 11, and 14 are in Group 4.

Students 1, 10, and 12 are in Group 15.

\*Attendance\* It appears that Group 1 has the highest percentage of meeting hours at 61%, indicating that a significant portion of the total meeting hours is attributed to this group. On the other hand, Group 5 has the least percentage, suggesting that they contribute the smallest share of meeting hours, amounting to 15%.

The remaining groups (presumably Groups 2, 3, and 4) have percentages of 60%, 50%, and 46%.

In summary, Group 1 is the most significant contributor, Group 5 is the least, and the other groups fall in between based on their respective percentages of meeting hours.

\*Experience\*

Group 1 consists of individuals with the highest level of experience, as indicated by the percentage of 205. On the contrary, Group 4, composed of students, has the least experience with a percentage of 86. The remaining groups, specifically Group 2, Group 3, and Group 5, have percentages of 206, 168, and 97, respectively. Group 1 has the most experienced individuals, Group 4 has the least experience (likely due to being students), and Groups 2, 3, and 5 fall in between with differing levels of experience.

\*\* GPA\*\*

It appears that Group 1 has the highest GPA percentage of 228, indicating that, on average, the members of this group have higher academic performance compared to the other groups. Conversely, Group 4 has the lowest GPA percentage of 119, suggesting that, on average, the members of this group have a comparatively lower academic performance. The remaining groups, specifically Group 2, Group 3, and Group 5, have GPA percentages of 140, 131, and 131, respectively. In summary, Group 1 has the highest average GPA, Group 4 (students) has the lowest, and Groups 2, 3, and 5 fall in between with differing levels of academic performance.

**CONCLUSION:**

In conclusion, the detailed analysis of key factors, including meeting hours, experience, and GPA, highlights Group 1 as a standout performer across all criteria. With the highest meeting hours, most experienced individuals, and the top GPA percentage, Group 1 exhibits a well-rounded profile. Conversely, Group 5 consistently ranks lower in these factors, with the least meeting hours, experience, and a comparatively lower GPA.

While Group 1 appears to excel individually, the overall success of the project depends on a holistic evaluation of various skills and capabilities within each group. Effective teamwork, adaptability to project requirements, and a collaborative approach will be crucial for the collective success of all groups. The assignment of students to different groups based on their strengths and capabilities, as outlined, aims to optimize the chances of success for each group in the class project.

**APPENDIX**

QMM\_Final

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2023-12-06

**Problem Statement**

We have been asked to assign 15 students to a group project.

Division: The 15 students has been put into five different groups which means each group has 3 students.

We have determined that attendance, experience and GPA are the three main criteria that have a big impact on how well groups complete the project. To get the best results possible on the class project, each of these elements is essential.

**Generating the data**

1. Attendance

set.seed(1)  
Attendance <- round(runif(15, min = 0, max = 30))  
print(Attendance)

## [1] 8 11 17 27 6 27 28 20 19 2 6 5 21 12 23

Mean\_A <- round(weighted.mean(Attendance))  
Mean\_A

## [1] 15

1. Experience

set.seed(2)  
Experience <- round(runif(15, min = 0, max = 100))  
print(Experience)

## [1] 18 70 57 17 94 94 13 83 47 55 55 24 76 18 41

Mean\_E <- round(weighted.mean(Experience))  
Mean\_E

## [1] 51

1. GPA PERCENTAGE

set.seed(3)  
GPA <- round(runif(15, min = 0, max = 100))  
print(GPA)

## [1] 17 81 38 33 60 60 12 29 58 63 51 51 53 56 87

Mean\_G <- round(weighted.mean(GPA))  
Mean\_G

## [1] 50

**Creating data frame**

data <- data.frame(student=1:15,Attendance, Experience, GPA)  
data

## student Attendance Experience GPA  
## 1 1 8 18 17  
## 2 2 11 70 81  
## 3 3 17 57 38  
## 4 4 27 17 33  
## 5 5 6 94 60  
## 6 6 27 94 60  
## 7 7 28 13 12  
## 8 8 20 83 29  
## 9 9 19 47 58  
## 10 10 2 55 63  
## 11 11 6 55 51  
## 12 12 5 24 51  
## 13 13 21 76 53  
## 14 14 12 18 56  
## 15 15 23 41 87

Average <- rowMeans(data[, c("Attendance", "Experience", "GPA")])  
round(Average)

## [1] 14 54 37 26 53 60 18 44 41 40 37 27 50 29 50

data$Average <- round(Average)  
data

## student Attendance Experience GPA Average  
## 1 1 8 18 17 14  
## 2 2 11 70 81 54  
## 3 3 17 57 38 37  
## 4 4 27 17 33 26  
## 5 5 6 94 60 53  
## 6 6 27 94 60 60  
## 7 7 28 13 12 18  
## 8 8 20 83 29 44  
## 9 9 19 47 58 41  
## 10 10 2 55 63 40  
## 11 11 6 55 51 37  
## 12 12 5 24 51 27  
## 13 13 21 76 53 50  
## 14 14 12 18 56 29  
## 15 15 23 41 87 50

*Creating the table of students along with the factors and their values*

table <- matrix(c(1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,  
 8,11,17,27,6,27,28,20,19,2,6,5,21,12,23,  
 18,70,57,17,94,94,13,83,47,55,55,24,76,18,41,  
 17,81,38,33,60,60,12,29,58,63,51,51,53,56,87,  
 14, 54, 37, 26, 53, 60, 18, 44, 41, 40, 37, 27, 50, 29, 50),ncol = 5,byrow = F)  
  
colnames(table) <- c("Student\_No","Attendance","Experience","GPA","Average")  
rownames(table) <- c(1:15)  
  
as.table(table)

## Student\_No Attendance Experience GPA Average  
## 1 1 8 18 17 14  
## 2 2 11 70 81 54  
## 3 3 17 57 38 37  
## 4 4 27 17 33 26  
## 5 5 6 94 60 53  
## 6 6 27 94 60 60  
## 7 7 28 13 12 18  
## 8 8 20 83 29 44  
## 9 9 19 47 58 41  
## 10 10 2 55 63 40  
## 11 11 6 55 51 37  
## 12 12 5 24 51 27  
## 13 13 21 76 53 50  
## 14 14 12 18 56 29  
## 15 15 23 41 87 50

**Mathematical formulation**

Objective function:

**constraints**

**Student constraint**

Each student is assigned to exactly one group.

**Group constraint**

Each group should have exactly 3 members.

**Non-Negativity constraint**

**Factor constraints**

**Attendance constraint**

The number of hours group members are attending the meetings scheduled for the project.

**Experience constraint**

Experience in the related field, their experience is rated from 0 to 100. 1 being the lowest and 10 being the highest.

**GPA constraint**

The students have been scaled on a percentage from 0 to 100 where 0% being given to the student with least overall grade and 100% to students with the highest overall grade.

**Mathematical formulation of the constraints**

**Objective function**

where “g” is group ranging from 1 to 5 and “x” is students ranging from 1 to 15

**constraint**

**Group constraint**

**Attendance constraint**

For group 1: 8g1x1 + 11g1x2 + 17g1x3 + 27g1x4 + 6g1x5 + 27g1x6 + 28g1x7 + 20g1x8 + 19g1x9 + 2g1x10 + 6g1x11 + 5g1x12 + 21g1x13 + 12g1x14 + 23g1x15 >=15

For group 2: 8g2x1 + 11g2x2 + 17g2x3 + 27g2x4 + 6g2x5 + 27g2x6 + 28g2x7 + 20g2x8 + 19g2x9 + 2g2x10 + 6g2x11 + 5g2x12 + 21g2x13 + 12g2x14 + 23g2x15 >=15

For Group 3: 8g3x1 + 11g3x2 + 17g3x3 + 27g3x4 + 6g3x5 + 27g3x6 + 28g3x7 + 20g3x8 + 19g3x9 + 2g3x10 + 6g3x11 + 5g3x12 + 21g3x13 + 12g3x14 + 23g3x15 >=15

For Group 4: 8g4x1 + 11g4x2 + 17g4x3 + 27g4x4 + 6g4x5 + 27g4x6 + 28g4x7 + 20g4x8 + 19g4x9 + 2g4x10 + 6g4x11 + 5g4x12 + 21g4x13 + 12g4x14 + 23g4x15 >=15

For Group 5: 8g5x1 + 11g5x2 + 17g5x3 + 27g5x4 + 6g5x5 + 27g5x6 + 28g5x7 + 20g5x8 + 19g5x9 + 2g5x10 + 6g5x11 + 5g5x12 + 21g5x13 + 12g5x14 + 23g5x15 >=15

**Experience constraint**

For Group 1: 18g1x1 + 70g1x2 + 57g1x3 + 17g1x4 + 94g1x5 + 94g1x6 + 13g1x7 + 83g1x8 + 47g1x9 + 55g1x10 + 55g1x11 + 24g1x12 + 76g1x13 + 18g1x14 + 41g1x15 >=51

For Group 2: 18g2x1 + 70g2x2 + 57g2x3 + 17g2x4 + 94g2x5 + 94g2x6 + 13g2x7 + 83g2x8 + 47g2x9 + 55g2x10 + 55g2x11 + 24g2x12 + 76g2x13 + 18g2x14 + 41g2x15 >=51

For group 3: 18g3x1 + 70g3x2 + 57g3x3 + 17g3x4 + 94g3x5 + 94g3x6 + 13g3x7 + 83g3x8 + 47g3x9 + 55g3x10 + 55g3x11 + 24g3x12 + 76g3x13 + 18g3x14 + 41g3x15 >=51

For group 4: 18g4x1 + 70g4x2 + 57g4x3 + 17g4x4 + 94g4x5 + 94g4x6 + 13g4x7 + 83g4x8 + 47g4x9 + 55g4x10 + 55g4x11 + 24g4x12 + 76g4x13 + 18g4x14 + 41g4x15 >=51

For group 5: 18g5x1 + 70g5x2 + 57g5x3 + 17g5x4 + 94g5x5 + 94g5x6 + 13g5x7 + 83g5x8 + 47g5x9 + 55g5x10 + 55g5x11 + 24g5x12 + 76g5x13 + 18g5x14 + 41g5x15 >=51

**GPA constraint**

For Group 1: 17g1x1 + 81g1x2 + 38g1x3 + 33g1x4 + 60g1x5 + 60g1x6 + 12g1x7 + 29g1x8 + 58g1x9 + 63g1x10 + 51g1x11 + 51g1x12 + 53g1x13 + 56g1x14 + 87g1x15 >=50

For Group 2: 17g2x1 + 81g2x2 + 38g2x3 + 33g2x4 + 60g2x5 + 60g2x6 + 12g2x7 + 29g2x8 + 58g2x9 + 63g2x10 + 51g2x11 + 51g2x12 + 53g2x13 + 56g2x14 + 87g2x15 >=50

For Group 3: 17g3x1 + 81g3x2 + 38g3x3 + 33g3x4 + 60g3x5 + 60g3x6 + 12g3x7 + 29g3x8 + 58g3x9 + 63g3x10 + 51g3x11 + 51g3x12 + 53g3x13 + 56g3x14 + 87g3x15 >=50

For Group 4: 17g4x1 + 81g4x2 + 38g4x3 + 33g4x4 + 60g4x5 + 60g4x6 + 12g4x7 + 29g4x8 + 58g4x9 + 63g4x10 + 51g4x11 + 51g4x12 + 53g4x13 + 56g4x14 + 87g4x15 >=50

For Group 5: 17g5x1 + 81g5x2 + 38g5x3 + 33g5x4 + 60g5x5 + 60g5x6 + 12g5x7 + 29g5x8 + 58g5x9 + 63g5x10 + 51g5x11 + 51g5x12 + 53g5x13 + 56g5x14 + 87g5x15 >=50

**Individual constraint**

1. g1x1+g2x1+g3x1+g4x1+g5x1=1
2. g1x2+g2x2+g3x2+g4x2+g5x2=1
3. g1x3+g2x3+g3x3+g4x3+g5x3=1
4. g1x4+g2x4+g3x4+g4x4+g5x4=1
5. g1x5+g2x5+g3x5+g4x5+g5x5=1
6. g1x6+g2x6+g3x6+g4x6+g5x6=1
7. g1x7+g2x7+g3x7+g4x7+g5x7=1
8. g1x8+g2x8+g3x8+g4x8+g5x8=1
9. g1x9+g2x9+g3x9+g4x9+g5x9=1
10. g1x10+g2x10+g3x10+g4x10+g5x10=1
11. g1x11+g2x11+g3x11+g4x11+g5x11=1
12. g1x12+g2x12+g3x12+g4x12+g5x12=1
13. g1x13+g2x13+g3x13+g4x13+g5x13=1
14. g1x14+g2x14+g3x14+g4x14+g5x14=1
15. g1x15+g2x15+g3x15+g4x15+g5x15=1

##Solving the problem in R.

### Loading required libraries.

library(lpSolve)  
library(lpSolveAPI)

### Gemerating a LP problem with both 35 constraints and 75 decision variables

LP\_model <- make.lp(35, 75)  
LP\_model

## Model name:   
## a linear program with 75 decision variables and 35 constraints

### LP\_model is an object that represents the LP problem.

#This statement sets the cofficients for the objective functions seventy five decision variables. It provides a vector containing these coefficients, emphasizing the importance of maintaining a consistent order for both the variables in the objective function and the constraints.

set.objfn(LP\_model, c(14, 54, 37, 26, 53, 60, 18, 44, 41, 40, 37, 27, 50, 29, 50,  
 14, 54, 37, 26, 53, 60, 18, 44, 41, 40, 37, 27, 50, 29, 50,  
 14, 54, 37, 26, 53, 60, 18, 44, 41, 40, 37, 27, 50, 29, 50,  
 14, 54, 37, 26, 53, 60, 18, 44, 41, 40, 37, 27, 50, 29, 50,  
 14, 54, 37, 26, 53, 60, 18, 44, 41, 40, 37, 27, 50, 29, 50))

### By setting the objective sense to “max” this line’s aim is to maximize the objective function.

lp.control(LP\_model, sense = 'max')

## $anti.degen  
## [1] "none"  
##   
## $basis.crash  
## [1] "none"  
##   
## $bb.depthlimit  
## [1] -50  
##   
## $bb.floorfirst  
## [1] "automatic"  
##   
## $bb.rule  
## [1] "pseudononint" "greedy" "dynamic" "rcostfixing"   
##   
## $break.at.first  
## [1] FALSE  
##   
## $break.at.value  
## [1] 1e+30  
##   
## $epsilon  
## epsb epsd epsel epsint epsperturb epspivot   
## 1e-10 1e-09 1e-12 1e-07 1e-05 2e-07   
##   
## $improve  
## [1] "dualfeas" "thetagap"  
##   
## $infinite  
## [1] 1e+30  
##   
## $maxpivot  
## [1] 250  
##   
## $mip.gap  
## absolute relative   
## 1e-11 1e-11   
##   
## $negrange  
## [1] -1e+06  
##   
## $obj.in.basis  
## [1] TRUE  
##   
## $pivoting  
## [1] "devex" "adaptive"  
##   
## $presolve  
## [1] "none"  
##   
## $scalelimit  
## [1] 5  
##   
## $scaling  
## [1] "geometric" "equilibrate" "integers"   
##   
## $sense  
## [1] "maximize"  
##   
## $simplextype  
## [1] "dual" "primal"  
##   
## $timeout  
## [1] 0  
##   
## $verbose  
## [1] "neutral"

### Adding constraints to the LP problem.

#Group 1  
set.row(LP\_model,1,c(1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
# Group 2  
set.row(LP\_model,2,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
# Group 3  
set.row(LP\_model,3,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
 # Group 4  
set.row(LP\_model,4,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))  
  
# Group 5  
set.row(LP\_model,5,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1))   
  
#Attendance constraint for group 1  
set.row(LP\_model,6,c(8,11,17,27,6,27,28,20,19,2,6,5,21,12,23,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Attendance constraint for group 2  
set.row(LP\_model,7,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8,11,17,27,6,27,28,20,19,2,6,5,21,12,23,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))  
  
#Attendance constraint for group 3  
set.row(LP\_model,8,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8,11,17,27,6,27,28,20,19,2,6,5,21,12,23,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))  
  
#Attendance constraint for group 4  
set.row(LP\_model,9,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8,11,17,27,6,27,28,20,19,2,6,5,21,12,23,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Attendance constraint for group 5  
set.row(LP\_model,10,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8,11,17,27,6,27,28,20,19,2,6,5,21,12,23))  
  
#Experience constraint for group 1  
set.row(LP\_model,11,c(18,70,57,17,94,94,13,83,47,55,55,24,76,18,41,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Experience constraint for group 2  
set.row(LP\_model,12,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,18,70,57,17,94,94,13,83,47,55,55,24,76,18,41,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Experience constraint for group 3  
set.row(LP\_model,13,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,18,70,57,17,94,94,13,83,47,55,55,24,76,18,41,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Experience constraint for group 4  
set.row(LP\_model,14,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,18,70,57,17,94,94,13,83,47,55,55,24,76,18,41,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Experience constraint for group 5  
set.row(LP\_model,15,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,18,70,57,17,94,94,13,83,47,55,55,24,76,18,41))  
  
#GPA constraint for group 1  
set.row(LP\_model,16,c(17,81,38,33,60,60,12,29,58,63,51,51,53,56,87,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#GPA constraint for group 2  
set.row(LP\_model,17,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,17,81,38,33,60,60,12,29,58,63,51,51,53,56,87,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0  
))   
  
#GPA constraint for group 3  
set.row(LP\_model,18,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,17,81,38,33,60,60,12,29,58,63,51,51,53,56,87,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#GPA constraint for group 4  
set.row(LP\_model,19,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,17,81,38,33,60,60,12,29,58,63,51,51,53,56,87,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0))  
  
#GPA constraint for group 5  
set.row(LP\_model,20,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,17,81,38,33,60,60,12,29,58,63,51,51,53,56,87))  
  
#Student 1 constraint  
set.row(LP\_model,21,c(1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Student 2 constraint  
set.row(LP\_model,22,c(0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Student 3 constraint  
set.row(LP\_model,23,c(0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0))   
  
#Student 4 constraint  
set.row(LP\_model,24,c(0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0))   
  
#Student 5 constraint  
set.row(LP\_model,25,c(0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0))   
  
#Student 6 constraint  
set.row(LP\_model,26,c(0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0))   
  
#Student 7 constraint  
set.row(LP\_model,27,c(0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0))   
  
#Student 8 constraint  
set.row(LP\_model,28,c(0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0))   
  
#Student 9 constraint  
set.row(LP\_model,29,c(0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0))   
  
#Student 10 constraint  
set.row(LP\_model,30,c(0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0))   
  
#Student 11 constraint  
set.row(LP\_model,31,c(0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0))   
  
#Student 12 constraint  
set.row(LP\_model,32,c(0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0))   
  
#Student 13 constraint  
set.row(LP\_model,33,c(0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0))  
  
#Student 14 constraint  
set.row(LP\_model,34,c(0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0))  
  
#Student 15 constraint  
set.row(LP\_model,35,c(0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1))

###Setting the right hand side values for the constraints in LP problem.

rhs<-c(rep(3,5), rep(15,5), rep(51,5), rep(51,5), rep(1,15))  
set.rhs(LP\_model,rhs)

### Setting the directions(Types) and bounds to the LP problem.

set.constr.type(LP\_model,c(rep("=",5),rep(">=", 15), rep("=",15)))  
set.bounds(LP\_model,lower = rep(0,75))

### Setting the type to integer

set.type(LP\_model, 1:75 ,type = "integer")

### Solving the Lp problem using the constraints and objective function.

solve(LP\_model)

## [1] 0

### Getting the value of objective function.

get.objective(LP\_model)

## [1] 580

### Getting the values of decision variables.

round(get.variables(LP\_model))

## [1] 0 1 0 0 0 1 0 0 0 0 0 0 0 0 1 0 0 0 0 0 0 0 1 1 0 0 0 1 0 0 0 0 1 1 1 0 0 0  
## [39] 0 0 0 0 0 0 0 0 0 0 0 0 0 1 0 0 0 1 0 0 1 0 1 0 0 0 0 0 0 0 0 1 0 1 0 0 0

### Getting the values of constraints.

get.constraints(LP\_model)

## [1] 3 3 3 3 3 61 60 50 46 15 205 206 168 86 97 228 140 131 119  
## [20] 131 1 1 1 1 1 1 1 1 1 1 1 1