Lecturer Teaching Scheduling that Minimize The Difference of Total Teaching Load Using Goal Programming

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Abstract. An implementation of scheduling problems is the scheduling of lecturers in educational institution. There are several considerations, including the availability of teaching time, the suitability between the subject and the lecturer’s field, and also the fairness of assignments for each lecturer. Because of these considerations, scheduling using operation research is needed to overcome the weaknesses of scheduling by conventional methods, which may not be able to cover several rules and conditions that need to be met. This scheduling problem can be solved by linear goal programming. In this work, two types of constraints need to be considered, i.e. hard and soft constraints. The hard constraints are some constraints that must be fulfilled, while the soft constraints are some constraints that hoped to be fulfilled as much as possible. In goal programming, the goal is minimizing the deviation variable, which may be able to make the soft constraints deviate from the expected value. This scheduling model is applied to the data of scheduling lecturers in the Department of Mathematics XYZ University. In this model, the main goal is minimizing the difference of total teaching load and it was achieved quite well because the total credits earned by each lecturer was quite same due to the limitation of deviation value. However, it makes the other goal wasn’t fulfilled, there are several lecturers who get schedules to teach courses outside their division.

1. Introduction
The involvement of educators such as teachers, lecturers, or tutors is an important element of academic activities. Because of that, the scheduling of educators in learning activities is quite crucial to maintain the performance of each educator. The scheduling of educators has to consider various aspects including the availability of teaching time, the suitability between the subject and the educator’s field, and the fairness of assignments for each educator. Since there are so many aspects that need to be considered, scheduling a large case using conventional methods can take a long time and it can’t be able to cover all the rules that need to be met or the expected conditions for each educator. The application of mathematical programming procedures has been used to allocate resources to the national education system in France for several years by more than 300 schools [1]. The mathematical concept mentioned before is a multiple goal model. This model is used to allocate teachers at a high school level by considering the targets that are desired by a school administrator and instructional staff [1]. Beside of that, goal programming has been implemented to the scheduling of exam invigilators [2], courses [3], volunteers [4], toolbooth collectors [5], and nurses [6]. In this paper, the educator’s scheduling model was applied to the hypothetical data of scheduling problems for lecturers in undergraduate and graduate education programs Department of Mathematics XYZ University to minimize the difference of total teaching load for each lecturer in each semester.
2. Linear goal programming
The ordinary linear programming (LP) model can’t solve some cases which require certain goals to be achieved simultaneously. This weakness was seen by A Charnes and W M Cooper who then developed a linear programming model in order to be able to solve these cases. The basic concept of the linear goal programming (LGP) model that they discovered was introduced in 1955 [7]. This technique was perfected and expanded by Jiri in the mid-sixties then Ignizio and Lee develop a complete explanation and several applications in the seventies [8].

The main difference between LGP and LP is in the structure and the using of the objective function. In LGP, the objective function in LP can be expressed as a goal constraint by put a deviational variable in the constraint to reflect how far the goal has been achieved and then combine the deviation variable in the objective function. In LP, the goal can be maximization or minimization. However, in LGP, the goal is only to minimize the deviations from certain goals. It shows that the goal of all LGP model is only minimization [8].

Since deviations from objectives are minimized, an LGP model can handle a wide variety of targets/objectives with different dimensions or different units of measurement. LGP also can handle a problem that has opposing goals. If there are multiple goals, the priority or ordinal sequence can be determined by us and the LGP finalization process will proceed and prioritized the highest priority goal to fulfilled it as good as possible before go to the lower priority goals [8].

Several components in linear goal programming are as follows [9].
1. decision variable: the same elements as in LP,
2. deviation variables (deviational/goal variable): a new element in LP but important in LGP,
3. system constraints: the constraints that are identical to the constraints in LP, without the deviation variables, and also known as hard constraints that are rigid,
4. goal constraints: the targets that want to be achieved by making it as a goal constraints, also known as soft constraints, and this contraints contain the deviation variables,
5. objective function: minimizing the total of deviation variables.

Let $\eta_i$ be the negative deviation of goal $i$ and $\rho_i$ is the positive deviation. To satisfy the target, the "unwanted" component (the deviation from the target) needs to be minimized [10]. This is summarized in Table 1.

| Initial form of goal (or rigid constraints) | Converted form | Deviation variables to be minimized |
|--------------------------------------------|----------------|-----------------------------------|
| $f_i(x) \geq b_i$                         | $f_i(x) + \eta_i - \rho_i = b_i$ | $\eta_i$                          |
| $f_i(x) < b_i$                             | $f_i(x) + \eta_i - \rho_i = b_i$ | $\rho_i$                          |
| $f_i(x) = b_i$                             | $f_i(x) + \eta_i - \rho_i = b_i$ | $\eta_i + \rho_i$                |

3. Model description and structure

3.1. Model description
The scheduling problem discussed in this paper is the scheduling of lecturers in lecture sessions and practicum sessions at the Department of Mathematics XYZ University. There are three education programs in this department, i.e. Undergraduate Program of Mathematics, Undergraduate Program of Actuarial Science, and Graduate Program of Applied Mathematics. There are 29 lecturers who have different education level. There are 12 lecturers who have master degree and 17 lecturers who have doctoral degree. The lecturer’s areas of expertise include pure mathematics, industrial mathematics and operations research, financial mathematics and capital markets, actuarial mathematics and demography, computational mathematics, stochastic modeling, modeling of various phenomena using differential equations, and modeling of environmental problems. The lecturer’s expertise synergized into five divisions below:
1 Division A is pure mathematics,
2 Division B is computational mathematics,
3 Division C is industrial mathematics and operations research,
4 Division D is financial mathematics, capital markets, and actuarial science,
5 Division E is mathematical modeling include stochastic modeling, modeling various phenomena using differential equations, and modeling environmental problems.

In this case, the lecturers scheduling have to use several assumptions:
1 the schedule of courses and the classrooms has been determined before applying this model,
2 the practicum sessions are handled by the lecturers (the practicum sessions that are carried out by the practicum assistants have been removed from the model).

The rules that must be fulfilled in lecturers scheduling are:
1 in one class (whether lecture or practicum session) there must be just one lecturer who teaches,
2 the lecturers do not get several schedules to teach two or more lecture at the same time (do not overlapping),
3 some lecturers can’t teach on certain days, certain intervals, certain schedules, consecutive schedules, and so on,
4 the lecture sessions for graduate program (not practicum sessions) have to taught by lecturers who have doctoral degree,
5 for several courses, both lecture session and practicum session need to be carried out by the same lecturer.

Beside the rules that must be fulfilled, there are several things that are expected to be fulfilled in lecturers scheduling:
1 each lecturer gets the same amount of teaching load (credits) in each semester,
2 a lecturer do not teach the same course in more than one parallel class in the same half of semester (mid-semester session and end-semester session),
3 each lecturer teaches courses that accordance to their expertise/division,
4 each lecturer teaches courses that are his/her main preference.

Here it is the courses schedule that need to be handled by the lecturers. This schedule contains information about index number for each class, the name and the schedule of the course, the teaching load (credit) for lecturers to that course, and the division for that course. In Table 2 below, it’s a courses schedule for Graduate Program of Applied Mathematics XYZ University.

| j  | Course                                      | Credit for mid-semester | Credit for end-semester | Schedule         | Division |
|----|---------------------------------------------|--------------------------|-------------------------|------------------|----------|
| 1  | Financial Mathematics and Capital Markets (P) | 0.5                      | 0.5                     | Monday, 8.00-9.40 | D        |
| 2  | Financial Mathematics and Capital Markets (L) | 1.0                      | 1.0                     | Thursday, 13.00-14.40 | D        |
| 3  | Numerical Analysis (L)                      | 1.0                      | 1.0                     | Wednesday, 8.00-9.40 | B        |
| 4  | Numerical Analysis (P)                      | 0.5                      | 0.5                     | Thursday, 10.00-11.40 | B        |
| 5  | Mathematical Modeling (L)                   | 1.0                      | 1.0                     | Monday, 13.00-14.40 | E        |
| 6  | Mathematical Modeling (P)                   | 0.5                      | 0.5                     | Tuesday, 13.00-14.40 | E        |
| 7  | Stochastic Process (L)                      | 1.0                      | 1.0                     | Tuesday, 8.00-9.40 | E        |
| 8  | Stochastic Process (P)                      | 0.5                      | 0.5                     | Friday, 13.00-14.40 | E        |
| 9  | Linear and Non-linear Programming (L)        | 1.0                      | 1.0                     | Monday, 10.00-11.40 | C        |
| 10 | Linear and Non-linear Programming (P)        | 0.5                      | 0.5                     | Thursday, 8.00-9.40 | C        |

Information: L = Lecture session, P = Practicum session.

This is the courses schedule for undergraduate program.
### Table 3. Courses schedule for undergraduate program

| \( j \) | Course | Credit for mid-semester | Credit for end-semester | Schedule | Division |
|--------|--------|-------------------------|-------------------------|----------|----------|
| 11     | Actuarial Mathematics 1 (ACT) (L) | 1.5 | 1.5 | Monday, 10.00-12.30 | D |
| 12     | Financial Mathematics (MAT) (L) | 1.5 | 1.5 | Monday, 13.00-15.30 | D |
| 13     | Actuarial Mathematics 1 (OTHER) (L) | 1.5 | 1.5 | Monday, 13.00-15.30 | D |
| 14     | Actuarial Mathematics 1 (MAT) (L) | 1.5 | 1.5 | Tuesday, 10.00-12.30 | D |
| 15     | Derivative Financial Modeling (ACT) (L) | 1.5 | 1.5 | Tuesday, 13.00-15.30 | D |
| 16     | Financial Mathematics (OTHER) (L) | 1.5 | 1.5 | Wednesday, 13.00-15.30 | D |
| 17     | Mathematics of Capital Markets (ACT) (L) | 1.5 | 1.5 | Wednesday, 7.30-10.00 | D |
| 18     | Risk Theory 1 (MAT) (L) | 1.5 | 1.5 | Wednesday, 8.00-10.30 | D |
| 19     | Introduction to Actuarial Science (ACT) (L) | 1.0 | 1.0 | Thursday, 10.00-11.40 | D |
| 20     | Risk Theory 1 (MAT) (P) | 0.5 | 0.5 | Thursday, 13.00-15.00 | D |
| 21     | Actuarial Statistical Methods 2 (ACT) (L) | 1.5 | 1.5 | Thursday, 7.30-10.00 | D |
| 22     | Actuarial Mathematics 1 (ACT) (P) | 0.5 | 0.5 | Friday, 9.00-11.00 | D |
| 23     | Real Analysis (MAT) (L) | 1.5 | 1.5 | Monday, 9.00-11.30 | A |
| 24     | Algebraic Structure (MAT) (L) | 1.5 | 1.5 | Tuesday, 7.30-10.00 | A |
| 25     | Real Analysis (MAT) (P) | 0.5 | 0.5 | Wednesday, 13.00-15.00 | A |
| 26     | Introduction to Mathematical Logic (MAT) (L) | 1.0 | 1.0 | Thursday, 10.00-11.40 | A |
| 27     | Analytic Geometry (MAT) (L) | 1.5 | 1.5 | Thursday, 10.00-12.30 | A |
| 28     | Introduction to Mathematical Logic (MAT) (P) | 0.5 | 0.5 | Thursday, 13.00-14.40 | A |
| 29     | Algebraic Structure (MAT) (P) | 0.5 | 0.5 | Friday, 9.00-11.00 | A |
| 30     | Mathematical Modeling (ACT) (L) | 1.0 | 1.0 | Monday, 15.00-16.40 | E |
| 31     | Introduction to Probability Theory (ACT) (L) | 1.0 | 1.0 | Monday, 8.00-9.40 | E |
| 32     | Basic Stochastic Process (MAT) (L) | 1.0 | 1.0 | Tuesday, 10.00-14.40 | E |
| 33     | Partial Differential Equation (MAT) (L) | 1.0 | 1.0 | Tuesday, 8.00-9.40 | E |
| 34     | Ordinary Differential Equation (ACT) (L) | 1.0 | 1.0 | Wednesday, 13.00-14.40 | E |
| 35     | Empirical Model Analysis (ACT) (L) | 1.0 | 1.0 | Wednesday, 13.00-14.40 | E |
| 36     | Ordinary Differential Equation (OTHER) (L) | 1.0 | 1.0 | Wednesday, 8.00-9.40 | E |
| 37     | Mathematical Statistics (MAT) (L) | 1.0 | 1.0 | Thursday, 8.00-9.40 | E |
| 38     | Linear Programming (OTHER) (L) | 1.0 | 1.0 | Tuesday, 10.00-11.40 | C |
| 39     | Linear Programming (MAT) (L) | 1.0 | 1.0 | Wednesday, 13.00-14.40 | C |
| 40     | Optimum Control (MAT) (L) | 1.5 | 1.5 | Thursday, 13.00-15.30 | C |
| 41     | Algorithmic Graph (MAT) (L) | 1.5 | 1.5 | Friday, 8.00-10.30 | C |
| 42     | Algorithmic Graph (OTHER) (L) | 1.5 | 1.5 | Friday, 13.30-16.00 | C |
| 43     | 3rd Calculus (OTHER) (L) | 1.0 | 1.0 | Thursday, 13.00-14.40 | General |
| 44     | 3rd Calculus (MAT) (L) | 1.0 | 1.0 | Thursday, 8.00-9.40 | General |
| 45     | 3rd Calculus (ACT) (L) | 1.0 | 1.0 | Thursday, 8.00-9.40 | General |
| 46     | 3rd Calculus (OTHER) (L) | 1.0 | 1.0 | Friday, 9.00-10.40 | General |

Information: MAT = Class for mathematics student, ACT = Class for actuarial science student, OTHER = Class for students outside Department of Mathematics, L = Lecture session, P = Practicum session.
Then, this is the list of lecturers in the Department of Mathematics XYZ University. In Table 4 below, the list contains information about index number for each lecturer, division, degree, and the unwanted schedule for each lecturers so that the lecturers will not mapped to their unwanted schedule.

**Table 4. List of lecturers**

| i  | Lecturer | Division | Degree     | Unwanted schedule                      |
|----|----------|----------|------------|----------------------------------------|
| 1  | A1       | A        | Doctoral   | -                                      |
| 2  | A2       | A        | Doctoral   | Tuesday, Wednesday                      |
| 3  | A3       | A        | Master     | -                                      |
| 4  | A4       | A        | Master     | -                                      |
| 5  | A5       | A        | Master     | -                                      |
| 6  | B1       | B        | Doctoral   | -                                      |
| 7  | B2       | B        | Master     | -                                      |
| 8  | B3       | B        | Master     | -                                      |
| 9  | B4       | B        | Doctoral   | Tuesday, Wednesday                      |
| 10 | C1       | C        | Doctoral   | Thursday, Friday, and a schedule with index \( j = 10 \) |
| 11 | C2       | C        | Doctoral   | -                                      |
| 12 | C3       | C        | Doctoral   | -                                      |
| 13 | C4       | C        | Master     | -                                      |
| 14 | C5       | C        | Master     | Consecutive schedule                    |
| 15 | C6       | C        | Master     | -                                      |
| 16 | D1       | D        | Doctoral   | Friday                                  |
| 17 | D2       | D        | Doctoral   | Tuesday                                |
| 18 | D3       | D        | Master     | -                                      |
| 19 | D4       | D        | Doctoral   | Tuesday, Wednesday                     |
| 20 | D5       | D        | Doctoral   | -                                      |
| 21 | D6       | D        | Doctoral   | Monday, Thursday afternoon              |
| 22 | D7       | D        | Master     | -                                      |
| 23 | E1       | E        | Doctoral   | -                                      |
| 24 | E2       | E        | Doctoral   | Monday                                 |
| 25 | E3       | E        | Master     | -                                      |
| 26 | E4       | E        | Doctoral   | -                                      |
| 27 | E5       | E        | Master     | Thursday, Friday                       |
| 28 | E6       | E        | Doctoral   | Tuesday, Thursday                      |
| 29 | E7       | E        | Doctoral   | -                                      |

From previous information about the condition that is expected to be fulfilled, there are several lecturers that have some preferences to teach certain courses. So that, there must be preference values for each lecture to the schedule or course that they want to teach. In this case, A1 have a preference to teach Analytic Geometry class in mid-semester session, A4 have a preference to teach Algebraic Structure course, both lecture and practicum, in mid-semester and end-semester session. Then, A5 have a preference to teach Analytic Geometry at end-semester session, E1 and E4 have the same preference to teach Stochastic Process and Basic Stochastic Process in mid-semester and end-semester session, and E6 have a preference to teach Empirical Model Analysis in both sessions.
Table 5. Preferences value for several lecturers

| j   | Lecture with index i, session-k | Mid | End | Mid | End | Mid | End | Mid | End | Mid | End | Mid | End |
|-----|---------------------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 7   |                                 | 5   | 5   | 5   | 5   |      |     |      |     |      |     |     |     |
| 8   |                                 | 5   | 5   | 5   | 5   |      |     |      |     |      |     |     |     |
| 24  |                                 | 5   | 5   | 5   | 5   |      |     |      |     |      |     |     |     |
| 26  |                                 | 2   | 2   | 2   | 2   |      |     |      |     |      |     |     |     |
| 27  |                                 | 10  |     |     |     |      |     |      |     |      |     |     |     |
| 28  |                                 | 2   | 2   | 2   | 2   |      |     |      |     |      |     |     |     |
| 29  |                                 | 1   | 1   | 10  | 10  | 1    | 1    |      |     |      |     |     |     |
| 32  |                                 |     |     |     |     |      |     |      |     |      |     |     |     |
| 35  |                                 |     |     |     |     |      |     |      |     |      |     |     | 10  |
| 35  |                                 |     |     |     |     |      |     |      |     |      |     |     | 10  |

4. Formulation

4.1. Indexes
There are 3 indexes in this model:
- \( i \) = index of each lecturer, \( i = 1, 2, \ldots, m \). In this case \( m = 29 \).
- \( j \) = index of each course schedule, \( j = 1, 2, \ldots, n \). In this case, \( n = 46 \).
- \( k \) = mid-semester session or end-semester session, \( k = 1 \) (mid semester session) and \( k = 2 \) (end semester session).

4.2. Sets
- \( L \) = a set for all of the lecturers
  = \{1, 2, \ldots, 29\}
- \( S \) = a set for all of the courses schedule
  = \{1, 2, \ldots, 46\}
- \( Doctoral \) = a set for the lecturers who have doctoral degree
  = \{1, 2, 6, 9, 10, 11, 12, 16, 17, 19, 20, 21, 23, 24, 26, 28, 29\}
- \( LD\text{iv}A \) = a set for the lecturers from Division A
  = \{1, 2, 3, 4, 5\}
- \( LD\text{iv}B \) = a set for the lecturers from Division B
  = \{6, 7, 8, 9\}
- \( LD\text{iv}C \) = a set for the lecturers from Division C
  = \{10, 11, 12, 13, 14, 15\}
- \( LD\text{iv}D \) = a set for the lecturers from Division D
  = \{16, 17, 18, 19, 20, 21, 22\}
- \( LD\text{iv}E \) = a set for the lecturers from Division E
  = \{23, 24, 25, 26, 27, 28, 29\}
- \( SD\text{iv}A \) = a set for the courses schedule from Division A
  = \{23, 24, 25, 26, 27, 28, 29\}
- \( SD\text{iv}B \) = a set for the courses schedule from Division B
  = \{3, 4\}
- \( SD\text{iv}C \) = a set for the courses schedule from Division C
  = \{9, 10, 38, 39, 40, 41, 42\}
- \( SD\text{iv}D \) = a set for the courses schedule from Division D
  = \{1, 2, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22\}
- \( SD\text{iv}E \) = a set for the courses schedule from Division E
  = \{5, 6, 7, 8, 30, 31, 32, 33, 34, 35, 36, 37\}
The hard constraints of the formulation are given below.

**SC**
- Set for several courses that have more than one class:
  \[ S_{ActMax} = \{11, 13, 14\}, \quad S_{ODE} = \{34, 36\}, \quad S_{Linprog} = \{39, 38\}. \]
  \[ I_{Graph} = \{41, 42\}, \quad \text{dan} \quad I_{Cals} = \{43, 44, 45, 46\}. \]

**SO**
- Set for several classes that occurred in the same time:
  \[ SO_1 = \{1, 23, 31\}, \quad SO_2 = \{9, 11, 23\}, \quad SO_3 = \{5, 12, 13, 30\}, \quad SO_4 = \{7, 24, 33\}, \]
  \[ SO_5 = \{14, 38\}, \quad SO_6 = \{6, 15, 32\}, \quad SO_7 = \{3, 17, 18, 36\}, \]
  \[ SO_8 = \{16, 25, 34, 35, 39\}, \quad SO_9 = \{10, 21, 37, 44, 45\}, \]
  \[ SO_{10} = \{4, 19, 26, 27\}, \quad SO_{11} = \{2, 20, 28, 40, 43\}, \]
  \[ SO_{12} = \{22, 29, 41, 46\}, \quad \text{and} \quad SO_{13} = \{8, 42\}. \]

**SC**
- Set for several classes that occurred in consecutive schedule:
  \[ SC_1 = \{1, 9\}, \quad SC_2 = \{1, 11\}, \quad SC_3 = \{31, 9\}, \quad SC_4 = \{31, 11\}, \quad SC_5 = \{23, 5\}, \]
  \[ SC_6 = \{23, 12\}, \quad SC_7 = \{23, 13\}, \quad SC_8 = \{9, 5\}, \quad SC_9 = \{9, 12\}, \quad SC_{10} = \{9, 13\}, \]
  \[ SC_{11} = \{11, 5\}, \quad SC_{12} = \{11, 12\}, \quad SC_{13} = \{11, 13\}, \quad SC_{14} = \{5, 30\}, \]
  \[ SC_{15} = \{12, 30\}, \quad SC_{16} = \{13, 30\}, \quad SC_{17} = \{7, 14\}, \quad SC_{18} = \{24, 14\}, \]
  \[ SC_{19} = \{33, 14\}, \quad SC_{20} = \{14, 6\}, \quad SC_{21} = \{14, 15\}, \quad SC_{22} = \{14, 32\}, \]
  \[ SC_{23} = \{10, 4\}, \quad SC_{24} = \{10, 19\}, \quad SC_{25} = \{10, 26\}, \quad SC_{26} = \{10, 27\}, \]
  \[ SC_{27} = \{21, 4\}, \quad SC_{28} = \{21, 19\}, \quad SC_{29} = \{21, 26\}, \quad SC_{30} = \{21, 27\}, \]
  \[ SC_{31} = \{37, 4\}, \quad SC_{32} = \{37, 19\}, \quad SC_{33} = \{37, 26\}, \quad SC_{34} = \{37, 27\}, \]
  \[ SC_{35} = \{44, 4\}, \quad SC_{36} = \{44, 19\}, \quad SC_{37} = \{44, 26\}, \quad SC_{38} = \{44, 27\}, \]
  \[ SC_{39} = \{45, 4\}, \quad SC_{40} = \{45, 19\}, \quad SC_{41} = \{45, 26\}, \quad SC_{42} = \{45, 27\}, \]
  \[ SC_{43} = \{4, 2\}, \quad SC_{44} = \{4, 20\}, \quad SC_{45} = \{4, 28\}, \quad SC_{46} = \{4, 40\}, \]
  \[ SC_{47} = \{4, 43\}, \quad SC_{48} = \{19, 2\}, \quad SC_{49} = \{19, 20\}, \quad SC_{50} = \{19, 28\}, \]
  \[ SC_{51} = \{19, 40\}, \quad SC_{52} = \{19, 43\}, \quad SC_{53} = \{26, 2\}, \quad SC_{54} = \{26, 20\}, \]
  \[ SC_{55} = \{26, 28\}, \quad SC_{56} = \{26, 40\}, \quad SC_{57} = \{26, 43\}, \quad SC_{58} = \{27, 2\}, \]
  \[ SC_{59} = \{27, 20\}, \quad SC_{60} = \{27, 28\}, \quad SC_{61} = \{27, 40\}, \quad SC_{62} = \{27, 43\}, \]
  \[ SC_{63} = \{7, 38\}, \quad SC_{64} = \{24, 38\}, \quad SC_{65} = \{33, 38\}, \quad SC_{66} = \{38, 6\}, \]
  \[ SC_{67} = \{38, 15\}, \quad \text{and} \quad SC_{68} = \{38, 32\}. \]

**SGrad**
- A set of several classes (lecture session) for graduate program
\[ = \{2, 3, 5, 7, 9\} \]

**SDay**
- Set of unwanted schedule for some lecturers:
  \[ SMon = \{1, 5, 9, 11, 12, 13, 23, 30, 31\}, \]
  \[ STue = \{6, 7, 14, 15, 24, 32, 33, 38\}, \]
  \[ SWed = \{3, 16, 17, 18, 25, 34, 35, 36, 39\}, \]
  \[ SThu1 = \{2, 4, 10, 19, 20, 21, 26, 27, 28, 37, 40, 43, 44, 45\}, \]
  \[ SThu2 = \{2, 20, 28, 40, 43\}, \quad \text{and} \quad SFri = \{8, 22, 29, 41, 42, 46\}. \]

### 4.3. Parameters

- credit_{j,k} = teaching load of class j at session k (refer to Table 2 and Table 3)
- pref_{i,j,k} = preference value of lecturer i for class j session k, this preference value just for lecturer with index i = 1, 4, 5, 23, 26, 28 (refer to Table 5).

### 4.4. Decision variable

\[ x_{i,j,k} = \begin{cases} 1, \quad \text{lecturer } i \text{ have to teach class } j, \text{ in session } k \\ 0, \quad \text{others} \end{cases} \]

### 4.5. Hard constraints

By considering and seeing the rules that must be fulfilled, the courses schedule, and the list of lecturers. The hard constraints of the formulation are given below.
- In one class, there must be just one lecturer who teaches.
\[ \sum_{i=1}^{29} x_{i,j,k} = 1, \quad \forall j, k. \]  

- The lecturers can’t teach two or more classes at the same time (do not overlapping).

\[ \sum_{j \in S_{ij1}} x_{i,j,k} \leq 1, \quad \forall i, k, \]  
\[ \sum_{j \in S_{ij2}} x_{i,j,k} \leq 1, \quad \forall i, k, \]  
\[ \vdots \]  
\[ \sum_{j \in S_{ij13}} x_{i,j,k} \leq 1, \quad \forall i, k. \]  

- Several lecturers can’t teach on certain days, certain intervals, and certain schedules.

\[ \sum_{j \in STue} x_{i,j,k} = 0, \quad \sum_{j \in SWed} x_{i,j,k} = 0, \quad i = 2, 9, 19, \forall k, \]  
\[ \sum_{j \in STue} x_{i,j,k} = 0, \quad \sum_{j \in SWed} x_{i,j,k} = 0, \quad i = 2, 9, 19, \forall k, \]  
\[ \sum_{j \in SThu1} x_{i,j,k} = 0, \quad \sum_{j \in SFri} x_{i,j,k} = 0, \quad i = 10, 27, \forall k, \]  
\[ \sum_{j \in STue} x_{i,j,k} = 0, \quad \sum_{j \in SThu1} x_{i,j,k} = 0, \quad i = 28, \forall k, \]  
\[ \sum_{j \in SMon} x_{i,j,k} = 0, \quad \sum_{j \in SThu2} x_{i,j,k} = 0, \quad i = 21, \forall k, \]  
\[ \sum_{j \in SMon} x_{i,j,k} = 0, \quad i = 24, \forall k, \]  
\[ \sum_{j \in STue} x_{i,j,k} = 0, \quad i = 17, \forall k, \]  
\[ \sum_{j \in SFri} x_{i,j,k} = 0, \quad i = 16, \forall k, \]  
\[ x_{10,10,k} = 0, \forall k. \]  

Beside of that, it’s known that C5 can’t teach in consecutive schedule. Here it is the mathematical formulation of this condition. It means that C5 will only get maximum one schedule in a consecutive schedule.

\[ \sum_{j \in SC_1} x_{14,j,k} \leq 1, \forall k, \]  
\[ \sum_{j \in SC_2} x_{14,j,k} \leq 1, \forall k, \]  
\[ \vdots \]  
\[ \sum_{j \in SC_{68}} x_{14,j,k} \leq 1, \forall k. \]  

- The lecture session for graduate program (not practicum sessions) have to taught by lecturers who have doctoral degree.
\[
\sum_{i \in \text{Doctoral}} x_{i,j,k} = 1, \quad \forall j, \quad \forall k \in SGrad. \quad (17)
\]

- In several courses that have lecture session and practicum session, both of the session need to be carried out by the same lecturer. In graduate program, that courses are Financial Mathematics and Capital Markets and also Stochastic Process. In undergraduate program, that courses are Risk Theory 1, Real Analysis, dan Algebraic Structure.

\[
x_{i,1,k} - x_{i,2,k} = 0, \quad \forall i, k, \quad (18)
\]
\[
x_{i,7,k} - x_{i,8,k} = 0, \quad \forall i, k, \quad (19)
\]
\[
x_{i,18,k} - x_{i,20,k} = 0, \quad \forall i, k, \quad (20)
\]
\[
x_{i,23,k} - x_{i,25,k} = 0, \quad \forall i, k, \quad (21)
\]
\[
x_{i,24,k} - x_{i,29,k} = 0, \quad \forall i, k. \quad (22)
\]

4.6. Soft constraints

Beside the rules that must be fulfilled, there are several goals that are expected to be fulfilled in this lecturers scheduling.

- The first goal is each lecturer gets the same amount of teaching load (credits) in each semester.

\[
\sum_{j=1}^{n} \sum_{k=1}^{2} \text{credit}_{j,k} x_{i,j,k} = \frac{\sum_{j=1}^{n} \sum_{k=1}^{2} \text{credit}_{j,k}}{m}, \quad \forall i, \quad (23)
\]

- The second goal is lecturer do not teach the same course in more than one parallel class in the same half of semester (mid-semester session and end-semester session), the courses that have more than one class are Actuarial Mathematics, Ordinary Differential Equation, Linear Programming, Algorithmic Graph, and 3rd Calculus.

\[
\sum_{j \in \text{ActMat}} x_{i,j,k} = 1, \quad \forall i, k, \quad (24)
\]
\[
\sum_{j \in \text{ODE}} x_{i,j,k} = 1, \quad \forall i, k, \quad (25)
\]
\[
\sum_{j \in \text{Linprog}} x_{i,j,k} = 1, \quad \forall i, k, \quad (26)
\]
\[
\sum_{j \in \text{Graph}} x_{i,j,k} = 1, \quad \forall i, k, \quad (27)
\]
\[
\sum_{j \in \text{Cal3}} x_{i,j,k} = 1, \quad \forall i, k. \quad (28)
\]

- The third soft constraint is each lecturer teaches courses that accordance to their expertise/division.

\[
\sum_{j \in \text{SDivA}} x_{i,j,k} = 0, \quad \forall i \in LDivA, \forall k, \quad (29)
\]
\[
\sum_{j \in \text{SDivB}} x_{i,j,k} = 0, \quad \forall i \in LDivB, \forall k, \quad (30)
\]
\[
\sum_{j \in \text{SDivC}} x_{i,j,k} = 0, \quad \forall i \in LDivC, \forall k, \quad (31)
\]
\[
\sum_{j \in \text{SDivD}} x_{i,j,k} = 0, \quad \forall i \in LDivD, \forall k, \quad (32)
\]
\[
\sum_{j \in \text{SDivE}} x_{i,j,k} = 0, \quad \forall i \in LDivE, \forall k. \quad (33)
\]
Goal/soft constraints do not have to absolutely fulfilled but expected to be fulfilled. Because of that, the deviation variables added to know how far the result deviate from the expected conditions. The deviation variables contained in this model are:

\[ d1_i^+ = \text{positive deviation for goal 1, lecturer } i, \]
\[ d1_i^- = \text{negative deviation for goal 1, lecturer } i, \]
\[ d2a_{i,k}^+ = \text{positive deviation for goal 2a, lecturer } i, \text{ session } k, \]
\[ d2a_{i,k}^- = \text{negative deviation for goal 2a, lecturer } i, \text{ session } k, \]
\[ d2b_{i,k}^+ = \text{positive deviation for goal 2b, lecturer } i, \text{ session } k, \]
\[ d2b_{i,k}^- = \text{negative deviation for goal 2b, lecturer } i, \text{ session } k, \]
\[ d2c_{i,k}^+ = \text{positive deviation for goal 2c, lecturer } i, \text{ session } k, \]
\[ d2c_{i,k}^- = \text{negative deviation for goal 2c, lecturer } i, \text{ session } k, \]
\[ d2d_{i,k}^+ = \text{positive deviation for goal 2d, lecturer } i, \text{ session } k, \]
\[ d2d_{i,k}^- = \text{negative deviation for goal 2d, lecturer } i, \text{ session } k, \]
\[ d2e_{i,k}^+ = \text{positive deviation for goal 2e, lecturer } i, \text{ session } k, \]
\[ d2e_{i,k}^- = \text{negative deviation for goal 2e, lecturer } i, \text{ session } k, \]
\[ d3a_{i,k}^+ = \text{positive deviation for goal 3a, lecturer } i, \text{ session } k, \]
\[ d3a_{i,k}^- = \text{negative deviation for goal 3a, lecturer } i, \text{ session } k, \]
\[ d3b_{i,k}^+ = \text{positive deviation for goal 3b, lecturer } i, \text{ session } k, \]
\[ d3b_{i,k}^- = \text{negative deviation for goal 3b, lecturer } i, \text{ session } k, \]
\[ d3c_{i,k}^+ = \text{positive deviation for goal 3c, lecturer } i, \text{ session } k, \]
\[ d3c_{i,k}^- = \text{negative deviation for goal 3c, lecturer } i, \text{ session } k, \]
\[ d3d_{i,k}^+ = \text{positive deviation for goal 3d, lecturer } i, \text{ session } k, \]
\[ d3d_{i,k}^- = \text{negative deviation for goal 3d, lecturer } i, \text{ session } k, \]
\[ d3e_{i,k}^+ = \text{positive deviation for goal 3e, lecturer } i, \text{ session } k, \]
\[ d3e_{i,k}^- = \text{negative deviation for goal 3e, lecturer } i, \text{ session } k. \]

After adding the deviation variables, the goals becomes:

- The first goal is each lecturer gets the same amount of teaching load (credits) in each semester.

\[
\sum_{j=1}^{n} \sum_{k=1}^{2} \text{credit}_{j,k} \cdot x_{i,j,k} + d1_i^- - d1_i^+ = \frac{\sum_{j=1}^{n} \sum_{k=1}^{2} \text{credit}_{j,k}}{m}, \quad \forall i, \tag{34}
\]

Especially for the first goal, to make the difference between the average of credits and total credits for each lecture and is not too far away, the deviation variable in the first goal is limited so that the maximum value of positive deviation and negative deviation is 1.

\[
d1_i^- \leq 1, \tag{35}
\]
\[
d1_i^+ \leq 1. \tag{36}
\]

- The lecturers do not teach the same course in more than one parallel class in the same half of semester (mid-semester session and end-semester session).

\[
\sum_{j \in S_{\text{ActMat}}} x_{i,j,k} + d2a_{i,k}^- - d2a_{i,k}^+ = 1, \quad \forall i, k, \tag{37}
\]
\[
\sum_{j \in S_{\text{ODE}}} x_{i,j,k} + d2b_{i,k}^- - d2b_{i,k}^+ = 1, \quad \forall i, k, \tag{38}
\]
\[
\sum_{j \in S_{\text{Linprog}}} x_{i,j,k} + d2c_{i,k}^- - d2c_{i,k}^+ = 1, \quad \forall i, k. \tag{39}
\]
\[
\sum_{j \in \text{Graph}} x_{i,j,k} + d2d_{i,k}^- - d2d_{i,k}^+ = 1, \quad \forall i,k,
\]
(40)
\[
\sum_{j \in S_{\text{Cals}}} x_{i,j,k} + d2e_{i,k}^- - d2e_{i,k}^+ = 1, \quad \forall i,k.
\]
(41)

- The third is each lecturer teaches courses that accordance to their expertise/division.
\[
\sum_{j \in S_{\text{DivA}}} x_{i,j,k} + d3a_{i,k}^- - d3a_{i,k}^+ = 0, \quad \forall i \in LDivA, \forall k,
\]
(42)
\[
\sum_{j \in S_{\text{DivB}}} x_{i,j,k} + d3b_{i,k}^- - d3b_{i,k}^+ = 0, \quad \forall i \in LDivB, \forall k,
\]
(43)
\[
\sum_{j \in S_{\text{DivC}}} x_{i,j,k} + d3c_{i,k}^- - d3c_{i,k}^+ = 0, \quad \forall i \in LDivC, \forall k,
\]
(44)
\[
\sum_{j \in S_{\text{DivD}}} x_{i,j,k} + d3d_{i,k}^- - d3d_{i,k}^+ = 0, \quad \forall i \in LDivD, \forall k,
\]
(45)
\[
\sum_{j \in S_{\text{DivE}}} x_{i,j,k} + d3e_{i,k}^- - d3e_{i,k}^+ = 0, \quad \forall i \in LDivE, \forall k.
\]
(46)

The last expected condition about the lecturers teaches courses that are his/her main preference will not build as a goal constraint but the value of preferences will added into the objective function.

4.7. Objective function

The objective function from goal programming is minimizing deviation variables from soft constraints. For the second and third goal, according to the concept about goal programming, the deviation variables that will be minimized just the positive deviations.

\[
\min \sum_{i=1}^{29} (d1_i^- + d1_i^+) + \sum_{i=1}^{29} \sum_{k=1}^{2} d2a_{i,k}^+ + d2b_{i,k}^+ + d2c_{i,k}^+ + d2d_{i,k}^+ + d2e_{i,k}^+ + d3a_{i,k}^+ + d3b_{i,k}^+ + d3c_{i,k}^+ + d3d_{i,k}^+ + d3e_{i,k}^+
\]

The next objective function is to maximize the preference value of certain lecturers who want to teach the desired courses schedules so that it is expected that the results of this model can make these lecturers mapped to the desired schedules. The preference values can be seen in Table 5. The following is the objective function to maximize preference values or minimize the negative of the total values.

\[
\min \left( \sum_{j=1}^{46} \sum_{k=1}^{2} \text{pref}_{i,j,k} x_{i,j,k} \right), \text{ for } i = 1, 4, 5, 23, 26, 28.
\]

From the objective functions that have been mentioned before, a whole objective function is a combination of all the objective functions before and this whole objective function will be used for this model.

\[
\min \sum_{i=1}^{29} (d1_i^- + d1_i^+)
\]
\[
+ \left( \sum_{i=1}^{29} \sum_{k=1}^{2} d2a_{i,k}^+ + d2b_{i,k}^+ + d2c_{i,k}^+ + d2d_{i,k}^+ + d2e_{i,k}^+ + d3a_{i,k}^+ + d3b_{i,k}^+ + d3c_{i,k}^+ + d3d_{i,k}^+ + d3e_{i,k}^+ \right) - \left( \sum_{j=1}^{46} \sum_{k=1}^{2} \text{pref}_{i,j,k} x_{i,j,k} \right)
\]

5. Results and Discussions

The lecturers scheduling model in the Department of Mathematics XYZ University was solved using the LINGO 11.0 software. Table 6 below shows the result of goal 1.

| i | Lecturer | Division | Degree | Total credits | \(d1^+_i\) | \(d1^-_i\) |
|---|----------|----------|--------|--------------|-------|-------|
| 1 | A1       | A        | Doctoral | 3.5          | 0.0   | 0.0   |
| 2 | A2       | A        | Doctoral | 3.5          | 0.0   | 0.0   |
| 3 | A3       | A        | Master  | 4.0          | 0.0   | 0.5   |
| 4 | A4       | A        | Master  | 4.0          | 0.0   | 0.5   |
| 5 | A5       | A        | Master  | 3.5          | 0.0   | 0.0   |
| 6 | B1       | B        | Doctoral | 3.0          | 0.5   | 0.0   |
| 7 | B2       | B        | Master  | 3.5          | 0.0   | 0.0   |
| 8 | B3       | B        | Master  | 3.5          | 0.0   | 0.0   |
| 9 | B4       | B        | Doctoral | 2.5          | 1.0   | 0.0   |
| 10| C1       | C        | Doctoral | 3.5          | 0.0   | 0.0   |
| 11| C2       | C        | Doctoral | 3.0          | 0.5   | 0.0   |
| 12| C3       | C        | Doctoral | 3.5          | 0.0   | 0.0   |
| 13| C4       | C        | Master  | 3.5          | 0.0   | 0.0   |
| 14| C5       | C        | Master  | 2.5          | 1.0   | 0.0   |
| 15| C6       | C        | Master  | 3.5          | 0.0   | 0.0   |
| 16| D1       | D        | Doctoral | 3.5          | 0.0   | 0.0   |
| 17| D2       | D        | Doctoral | 3.0          | 0.5   | 0.0   |
| 18| D3       | D        | Master  | 3.0          | 0.5   | 0.0   |
| 19| D4       | D        | Doctoral | 3.5          | 0.0   | 0.0   |
| 20| D5       | D        | Doctoral | 3.5          | 0.0   | 0.0   |
| 21| D6       | D        | Doctoral | 3.5          | 0.0   | 0.0   |
| 22| D7       | D        | Master  | 3.5          | 0.0   | 0.0   |
| 23| E1       | E        | Doctoral | 3.5          | 0.0   | 0.0   |
| 24| E2       | E        | Doctoral | 3.0          | 0.5   | 0.0   |
| 25| E3       | E        | Master  | 3.0          | 0.5   | 0.0   |
| 26| E4       | E        | Doctoral | 3.5          | 0.0   | 0.0   |
| 27| E5       | E        | Master  | 3.5          | 0.0   | 0.0   |
| 28| E6       | E        | Doctoral | 3.0          | 0.5   | 0.0   |
| 29| E7       | E        | Doctoral | 3.5          | 0.0   | 0.0   |

Table 6. List of the lecturers and their teaching load

In this case, the average of total credits that each lecturer can get is 3.5. In Table 6, it has been seen that the highest credit score that received by a lecturer is 4.0, it shows that the value of positive deviation is 0.5. Then, the smallest credit score is is 2.5, it shows that the negative deviation is 1.0.
### Table 7. The result of lecturers mapping in graduate program

| j  | Course                                                                 | Schedule            | Division | Mid-semester session | End-semester session |
|----|------------------------------------------------------------------------|---------------------|----------|----------------------|----------------------|
| 1  | Financial Mathematics and Capital Markets (P)                          | Monday, 8.00-9.40   | D        | D5                   | D4                   |
| 2  | Financial Mathematics and Capital Markets (L)                          | Thursday, 13.00-14.40 | D        | D5                   | D4                   |
| 3  | Numerical Analysis (L)                                                | Wednesday, 8.00-9.40 | B        | B1                   | B1                   |
| 4  | Numerical Analysis (P)                                                | Thursday, 10.00-11.40 | B        | B3                   | B2                   |
| 5  | Mathematical Modeling (L)                                             | Monday, 13.00-14.40 | E        | E7                   | E1                   |
| 6  | Mathematical Modeling (P)                                             | Tuesday, 13.00-14.40 | E        | E5                   | E7                   |
| 7  | Stochastic Process (L)                                                | Tuesday, 8.00-9.40  | E        | E1                   | E4                   |
| 8  | Stochastic Process (P)                                                | Friday, 13.00-14.40 | E        | E1                   | E4                   |
| 9  | Linear and Non-linear Programming (L)                                 | Monday, 10.00-11.40 | C        | C2                   | C1                   |
| 10 | Linear and Non-linear Programming (P)                                 | Thursday, 8.00-9.40 | C        | C3                   | C2                   |

Information: L = Lecture session, P = Practicum session.

### Table 8. The result of lecturers mapping in undergraduate program

| j  | Course                                                                 | Schedule            | Division | Mid-semester session | End-semester session |
|----|------------------------------------------------------------------------|---------------------|----------|----------------------|----------------------|
| 11 | Actuarial Mathematics 1 (ACT) (L)                                      | Monday, 10.00-12.30 | D        | C1                   | D7                   |
| 12 | Financial Mathematics (MAT) (L)                                        | Monday, 13.00-15.30 | D        | B4                   | D3                   |
| 13 | Actuarial Mathematics 1 (OTHER) (L)                                    | Monday, 13.00-15.30 | D        | B2                   | D1                   |
| 14 | Actuarial Mathematics 1 (MAT) (L)                                      | Tuesday, 10.00-12.30 | D        | B3                   | D6                   |
| 15 | Derivative Financial Modeling (ACT) (L)                                | Tuesday, 13.00-15.30 | D        | B2                   | B3                   |
| 16 | Financial Mathematics (OTHER) (L)                                      | Wednesday, 13.00-15.30 | D        | D3                   | D2                   |
| 17 | Mathematics of Capital Markets (ACT) (L)                               | Wednesday, 7.30-10.00 | D        | D2                   | D6                   |
| 18 | Risk Theory 1 (MAT) (L)                                                | Wednesday, 8.00-10.30 | D        | D7                   | D5                   |
| 19 | Introduction to Actuarial Science (ACT) (L)                            | Thursday, 10.00-11.40 | D        | D1                   | D1                   |
| 20 | Risk Theory 1 (MAT) (P)                                                | Thursday, 13.00-15.00 | D        | D7                   | D5                   |
| 21 | Actuarial Statistical Methods 2 (ACT) (L)                              | Thursday, 7.30-10.00 | D        | D4                   | A2                   |
| 22 | Actuarial Mathematics 1 (ACT) (P)                                      | Friday, 9.00-11.00  | D        | D6                   | D4                   |
| 23 | Real Analysis (MAT) (L)                                                | Monday, 9.00-11.30  | A        | A3                   | A3                   |
| 24 | Algebraic Structure (MAT) (L)                                          | Tuesday, 7.30-10.00 | A        | A4                   | A4                   |
| 25 | Real Analysis (MAT) (P)                                                | Wednesday, 13.00-15.00 | A        | A3                   | A3                   |
| 26 | Introduction to Mathematical Logic (MAT) (L)                           | Thursday, 10.00-11.40 | A        | A5                   | A1                   |
| 27 | Analytic Geometry (MAT) (L)                                            | Thursday, 10.00-12.30 | A        | A1                   | A5                   |
| 28 | Introduction to Mathematical Logic (MAT) (P)                           | Thursday, 13.00-14.40 | A        | A5                   | A5                   |
| 29 | Algebraic Structure (MAT) (P)                                          | Friday, 9.00-11.00  | A        | A4                   | A4                   |
| 30 | Mathematical Modeling (ACT) (L)                                        | Monday, 15.00-16.40 | E        | E5                   | E5                   |
| 31 | Introduction to Probability Theory (ACT) (L)                           | Monday, 8.00-9.40   | E        | E3                   | E3                   |
| 32 | Basic Stochastic Process (MAT) (L)                                     | Tuesday, 13.00-14.40 | E        | E4                   | E4                   |
In Table 9, it has been seen that goal 2 is totally fulfilled because the total deviation of goal 2 is 0. It’s shown in Table 7 and Table 8 that there are no lecturer who teach the same subject in more than one parallel class in the same half-semester (mid-semester or end-semester session). However, Table 9 shows the total deviation of goal 3 of 15. It means that there are 15 lecturers who teach courses outside their division. The detail value about the deviation variables for goal 3 is in Table 10 below.

Table 10. The total value of positive deviations from third goal

\[
\begin{align*}
\text{Total of deviation variables} & & \text{Value} \\
\sum_{k=1}^{2} \sum_{i=1}^{2} d2a_{i,k}^+ + d2b_{i,k}^+ + d2c_{i,k}^+ + d2d_{i,k}^+ + d2e_{i,k}^+ & & \text{The total of positive deviation for second goal} & & 0 \\
\sum_{k=1}^{2} \sum_{i=1}^{2} d3a_{i,k}^+ + d3b_{i,k}^+ + d3c_{i,k}^+ + d3d_{i,k}^+ + d3e_{i,k}^+ & & \text{The total of positive deviation for third goal} & & 15 \\
\end{align*}
\]

Information: MATH = Class for mathematics student, ACT = Class for actuarial science student, OTHER = Class for students outside Department of Mathematics, L = Lecture session, P = Practicum session.
It shows that the lecturers who get a schedule for cross-division courses are lecturers with index $i = 1, 2, 6, 7, 8, 9, 10, 13, 14, 29$. The lecturers are A1 and A2 who are lecturers in Division A, lecturers B1, B2, B3, and B4 who are lecturers in Division B, lecturers C1, C4, and C5 who are lecturers in Division C, and E7 who is lecturer in Division E. Table 11 shows the cross-division schedule obtained by the lecturer which is bolded and underlined below.

**Table 10.** The total value of positive deviations from third goal (continuation)

| $i$ | Total of deviation variables | Value |
|-----|-----------------------------|-------|
| $i = 8$ | $\sum_{k=1}^{2} d3a_{9,k}^+ + d3b_{9,k}^+ + d3c_{9,k}^+ + d3d_{9,k}^+ + d3e_{9,k}^+$ | 2 |
| $i = 9$ | $\sum_{k=1}^{2} d3a_{10,k}^+ + d3b_{10,k}^+ + d3c_{10,k}^+ + d3d_{10,k}^+ + d3e_{10,k}^+$ | 2 |
| $i = 10$ | $\sum_{k=1}^{2} d3a_{13,k}^+ + d3b_{13,k}^+ + d3c_{13,k}^+ + d3d_{13,k}^+ + d3e_{13,k}^+$ | 1 |
| $i = 13$ | $\sum_{k=1}^{2} d3a_{14,k}^+ + d3b_{14,k}^+ + d3c_{14,k}^+ + d3d_{14,k}^+ + d3e_{14,k}^+$ | 1 |
| $i = 14$ | $\sum_{k=1}^{2} d3a_{29,k}^+ + d3b_{29,k}^+ + d3c_{29,k}^+ + d3d_{29,k}^+ + d3e_{29,k}^+$ | 1 |

6. **Conclusion**

In this scientific paper, it has been shown that the scheduling of lecturers which aims to minimize the difference of the total teaching load in Department of Mathematics XYZ University can be solved by linear goal programming using LINGO 11.0 software. The formulation of this scheduling problem is based on conditions that absolutely need to be fulfilled and the conditions that expected. This problem uses linear goal programming because if the expected condition can’t be fulfilled completely, the deviation value of that condition is supposed to be as small as possible. The first target/goal was achieved quite well because the total credits earned by each lecturer was quite same due to the limitation of deviation value. The second target can be fulfilled without any deviation value. However, in the third target, there are several lecturers who get schedules to teach courses outside their division.
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