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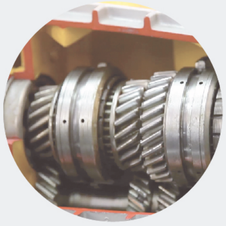

UM ALGORITMO DE APOIO À CRIAÇÃO DE HORÁRIOS NO ISEP-DEM

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A DECISION SUPPORT SYSTEM FOR THE UNIVERSITY COURSE TIMETABLING PROBLEM AT ISEP-DEM

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Instituto Superior de Engenharia do Porto

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Dissertation presented to *Instituto Superior de Engenharia do Porto* to fulfill the necessary requirements to obtain a master's degree in industrial and management Engineering, carried out under the guidance of Professor Manuel Pereira Lopes and co-supervision of Professor João Augusto Bastos.

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ABSTRACT

In this work, a decision support system (DSS) has been developed to support the creation of academic timetables at the *Instituto Superior de Engenharia do Porto* (ISEP), addressing the problem of university course timetabling. The DSS was designed to handle the scheduling of all years and regimes (day and evening) of undergraduate and postgraduate courses in the Department of Mechanical Engineering.

The motivation behind this project was to automate and optimise the timetabling process, which is currently done manually at ISEP. This manual process is complex, time consuming and requires significant effort from the faculty to create schedules based on historical data.

The solution used an integer mathematical programming approach, implemented using the Python programming language in conjunction with the CPLEX solver and the Pyomo library. The DSS was designed to integrate real-world data and handle a variety of constraints and preferences from both faculty and students. It aimed to reduce the time and human resources required to create the timetable.

The results show that the DSS provides feasible and efficient solutions for timetabling, significantly improving the resource allocation process and reducing manual effort. The successful implementation for two specific degrees suggests that the approach can be further developed to meet the scheduling needs of all degrees at ISEP, ultimately streamlining the scheduling process and meeting future demands.

KEY-WORDS

University Course Timetabling, Integer Programming, Optimization, Python Programming, CPLEX

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LIST OF SYMBOLS AND ACRONYMS

List of Acronyms

DSS	Decision Support System
DEM	*Departamento de Engenharia Mecânica*
ECTP	Examination Course Timetabling Problem
GA	Genetic Algorithm
IP	Integer Programming
ISEP	*Instituto Superior de Engenharia do Porto*
OT	Tutorial guidelines classes
P.Porto	*Instituto Politécnico do Porto*
PL	Practical-Laboratory classes
T	Theoretical classes
TP	Theoretical-Pratical classes
TS	Tabu Search
UCTP	University Course Timetabling Problem
SA	Simulated Annealing

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1. INTRODUCTION

This chapter introduces the project by outlining its context, objectives, and methodology. It begins with a brief description of the challenges faced by *Instituto Superior de Engenharia do Porto* (ISEP) in manually creating academic timetables. The chapter then highlights the significance of developing a decision support system (DSS) to improve efficiency and address these challenges.

Following this, the research question and objectives are presented, focusing on how the DSS aims to optimize timetable creation while reducing time and resource usage. Finally, an overview of the methodological approach is provided, detailing the use of quantitative methods and optimization techniques.

1.1. Context and Framework

This project was developed at the *Instituto Superior de Engenharia do Porto* (ISEP), one of the schools within the Polytechnic Institute of Porto. ISEP is an engineering school offering 13 undergraduate degrees and 15 master's degrees. The institution comprises nine departments, with this project specifically focused on the Department of Mechanical Engineering.

To date, university timetables at ISEP have been created manually. This process requires a significant investment of resources, both in terms of the faculty responsible for the task and the time spent ensuring the schedules are error-free. Consequently, this project aims to develop an algorithm to, address the University Course Timetabling Problem (UCTP).

1.2. Relevance and Importance

Modernizing and optimizing the timetabling process at ISEP, particularly in the Mechanical Engineering Department, is essential for improving operational efficiency and responsiveness to both faculty and student needs. The current manual method of creating schedules is labor-intensive, often requiring faculty to rely on past timetables and adjust. As the complexity of academic scheduling increases, with the need to balance various types of classes—such as theoretical, practical-laboratory, and seminars - against the availability of resources like classrooms and faculty, the limitations of this manual approach become increasingly apparent.

An automated algorithmic solution offers a way to alleviate these pressures, streamlining the scheduling process and ensuring that timetables are both efficient and adaptable. By automating the handling of hard constraints, which must be strictly observed, and soft constraints, which should be met as fully as possible, the algorithm can optimize resource allocation in ways that manual scheduling simply cannot achieve. This optimization is crucial for minimizing conflicts, such as overlapping class times or room shortages, which are common challenges in the timetabling process.

Furthermore, the development of such an algorithm aligns with broader trends in higher education, where institutions are increasingly leveraging technology to enhance administrative functions. The ability to quickly generate and adjust timetables in response to changing needs—whether due to new faculty preferences, unexpected room unavailability, or shifts in student enrollment—represents a significant improvement over traditional methods. This project, therefore, is not only critical for enhancing the efficiency of timetabling at ISEP but also reflects a growing recognition of the role that advanced technology plays in modern academic administration.

In this context, the implementation of an automated timetabling solution at ISEP is timely. As universities face increasing demands for flexibility and efficiency in managing their operations, the ability to adopt and integrate new technological solutions will be key to maintaining competitive and effective educational environments. This project addresses these needs directly, positioning ISEP to better meet the challenges of contemporary academic scheduling.

1.3. Research question and its objectives

Given the complexities and challenges inherent in the university course timetabling process, this research seeks to answer the critical question: How can the development of a DSS effectively support the solution of the university timetabling problem, thereby reducing the resources and time required?

This question arises from the need to enhance the efficiency of timetabling at the *Instituto Superior de Engenharia do Porto* (ISEP), particularly within the Mechanical Engineering Department (DEM), where the current manual process is time-consuming and resource intensive.

To thoroughly explore and answer this research question, the primary goal of the study is to develop and implement a DSS that can successfully navigate the stringent conditions and constraints of the timetabling process. This goal is underpinned by several specific objectives, each contributing to the overall success of the project:

- **Comprehensive Analysis of Current Restrictions and Requirements:** The first objective involves a detailed analysis of the existing constraints and requirements that must be considered during timetable creation. This includes identifying both hard constraints, which are non-negotiable, and soft constraints, which should be satisfied as much as possible. Understanding these parameters is crucial for designing an algorithm that can accommodate the full complexity of the timetabling process.
- **Characterization of Decision Variables and Constraints:** Once the current requirements are understood, the next objective is to characterize the decision variables and constraints within the specific environment of ISEP's DEM. This involves defining the various factors that influence scheduling, such as the availability of faculty, classrooms, and the specific needs of different types of classes (theoretical, practical, etc.). Accurately characterizing these elements is essential for ensuring that the algorithm operates effectively within its intended context.
- **Review of Existing Models and Contextual Adaptation:** A thorough review of previously implemented models will be conducted to identify their similarities and differences with the context of ISEP. This objective aims to draw lessons from past approaches, discerning which elements can be adapted or improved to meet the unique needs of this project. The review will provide a foundation for selecting or developing the most suitable algorithmic approach.
- **Selection and Adaptation of the Appropriate Model:** Based on the insights gained from the review, the most suitable model or method will be selected and adapted to fit the specific needs of the DEM. This process will involve tailoring the chosen approach to address the unique challenges of ISEP's scheduling environment, ensuring that it can handle the specific constraints and requirements identified earlier.

- **Implementation within the Department of Mechanical Engineering:** The developed algorithm will be implemented within the DEM, marking a significant milestone in the project. This objective involves the practical application of the algorithm to real-world data, transitioning from theoretical development to operational use.
- **Evaluation of Algorithmic Results:** After implementation, the algorithm's performance will be evaluated. The results produced by the algorithm will be compared with the existing manually created timetables to assess improvements in efficiency, resource allocation, and overall quality. This evaluation will provide critical feedback on the algorithm's effectiveness and areas for potential refinement.

1.4. Methodological options

The complexity and multifaceted nature of the University Course Timetabling Problem (UCTP) requires a carefully structured methodological approach. This project aims to create an algorithm that optimizes the construction of course schedules while accommodating current and future needs. To ensure the achievement of this goal, the chosen methodologies are aligned with the specific requirements of the problem and the broader objectives of the research.

The methodology for this study is grounded in quantitative research, which is particularly suited to the nature of timetabling problems in education. Given the algorithmic and mathematical approaches necessary for developing a viable solution, a quantitative framework allows for the precise analysis and modeling required to address the complexities of the UCTP.

The research structure was established by first gathering comprehensive information about the problem and its specific objectives. This foundational work laid out the necessary steps for the project's development:

- **Project Planning and Definition:** The initial phase involved defining the project's overall scope and goals. This step was crucial for setting clear objectives and ensuring that all subsequent methodological choices were geared towards achieving these goals.
- **Literature Review and Comparative Analysis:** The second and third phases involved a thorough literature review. By analyzing existing research on university timetabling problems and comparing it to the specific context of ISEP, the study aimed to identify the most effective approaches previously used in similar scenarios. This comparative analysis helped to pinpoint potential models or methods that could be adapted for use in this project.
- **Model Adaptation and Development:** The final phase of the research structure focused on adapting the chosen model to fit the specific requirements of ISEP's Mechanical Engineering Department. This step included modifying existing algorithms or models based on the insights gained from the literature review, ensuring that the solution would be tailored to the unique constraints and needs of the department.

The choice of a quantitative research approach was driven by the nature of the UCTP itself. Timetabling in an educational context is inherently quantitative, involving numerous variables and constraints that must be systematically analyzed and optimized. The use of mathematical models and algorithmic approaches provides a rigorous framework for handling these complexities and offers a pathway to developing a robust solution.

The systematic review conducted by (Bashab et al., 2020) was particularly influential in shaping the methodological approach of this study. Their review, which mapped 131 publications on university timetabling problems from 2009 to 2020, highlighted the prevalence and effectiveness of meta-heuristic algorithms in solving such problems. The findings that hybrid methods, particularly those combining meta-heuristic algorithms, represent a significant portion of successful applications underscored the importance of incorporating these techniques into the project.

Furthermore, the review identified emerging trends in meta-heuristic algorithms, such as the grey wolf optimizer and cat swarm optimization algorithms, which hold promise for delivering reliable and satisfactory results. These insights provided a compelling case for the selection of advanced algorithmic methods in this research, ensuring that the developed solution would not only address current scheduling needs but also be adaptable to future challenges and constraints.

The research plan was carefully designed to ensure that the chosen methodologies would effectively support the achievement of the project's objectives. After defining the problem and conducting a comprehensive literature review, the next steps focused on the practical application of these insights:

- **Algorithm Development:** Based on the chosen model, the algorithm was developed to optimize timetable construction within the Mechanical Engineering Department. This involved detailed programming and iterative testing to refine the algorithm's performance.
- **Implementation and Testing:** The developed algorithm was implemented in a real-world context within ISEP. Testing was conducted to ensure that the algorithm met the required standards and could handle the specific constraints of the department.
- **Evaluation and Optimization:** The final stages of the research involved evaluating the algorithm's performance against manually created timetables and optimizing its scalability.

By aligning the methodological choices with the specific demands of the UCTP at ISEP, this study aims to deliver a practical, efficient, and scalable solution. The careful selection of quantitative research methods, informed by a thorough review of existing literature and emerging trends, ensures that the project is well-positioned to meet its objectives and contribute to the broader field of educational timetabling.

1.5. Structures of the dissertation

This dissertation is organized into five main chapters, each addressing different aspects of the research on the University Course Timetabling Problem (UCTP) at the Mechanical Engineering Department of ISEP.

The Introduction chapter provides an overview of the project, outlining its context, objectives, and the methodological approach used. It also previews the structure of the dissertation.

Chapter Two, Literature Review, explores existing research on the timetabling problem, particularly focusing on university course timetabling. It reviews relevant models and methods, and introduces the model chosen for this study.

In Chapter Three, Methods and Applications, the dissertation details the research methods, including the current timetabling challenges, the adapted mathematical model, and the structure of the data and computational application used to validate the model.

Chapter Four presents the Results and Discussion, where the outcomes of the algorithm are analyzed and compared to the current manual timetabling process, highlighting improvements and discussing any limitations.

The final chapter, Conclusion, summarizes the research findings, discusses the project's limitations, and suggests areas for future research.

Following the main chapters, the dissertation includes References and Appendices that provide additional information supporting the research.

2. LITERATURE REVIEW

This chapter presents a comprehensive literature review to provide a framework for the developed work. Initially, key concepts related to timetabling are explained. This includes an exploration of various timetabling problems such as the School Timetabling Problem, the Examination Timetabling Problem, and the University Course Timetabling Problem. Through this review, a solid foundation is established to understand the context and challenges addressed by this project.

2.1. Educational timetabling

Educational timetabling, as defined by (Ceschia et al., 2023), involves the intricate task of scheduling professor-student meetings within predefined timeframes and locations. This seemingly straightforward task is complicated by the unique rules and constraints inherent in each educational institution. (Wren, 1996) further elucidates the complexity of timetabling as the allocation, subject to constraints, of given resources to objects being placed in space-time, with the aim of satisfying a set of desirable objectives as closely as possible.

As educational timetables continue to evolve, there is an increasing demand for innovative solutions capable of addressing the complexities inherent in scheduling academic activities.

According to Ceschia et al. (2023), three main problems are prominent in the educational timetabling domain:

1. **High-School Timetabling Problem (HTP):** Involves the weekly scheduling of all classes in a high school, ensuring that professors do not have overlapping classes and avoiding conflicts between classes.

2. **University Course Timetabling Problem (UCTP):** Encompasses the weekly scheduling of lectures for a set of university courses, with a focus on minimizing overlap between lectures of courses with shared students.

3. **University Examination Timetabling Problem (UETP):** Entails scheduling exams for a set of university courses, aiming to prevent overlap between exams of courses with common students and distributing exams evenly among students.

While other problems within the educational timetable have been addressed in the literature, they may not be relevant to the focus of the current project.

2.1.1. High-School Timetabling Problem (HTP)

High school timetabling problem can be defined in terms of the availability of professors and rooms, a number of lessons to be taught by professors to specific classes or students and a set of constraints. The construction of a timetable involves assigning resources, such as times, professors, students and rooms to a collection of lessons while minimizing the constraint violations (Fonseca et al., 2016). In this context, constraints refer to various factors such as professor availability, room capacity, and students' class schedules.

(Post et al., 2012a) reviewed several high school timetabling problems in different countries. They summarized a set of common constraints that are widely used and categorized the constraints into three groups: basic scheduling problem, constraints for the event, and constraints for resources.

Pillay (2014) further split the groups into seven groups: problem requirement constraints, no clash constraints, resources utilization constraints, workload constraints, period distribution constraints, preference constraints and lesson constraints. Here, we present some specific constraints so that readers can have a better understanding of the problem. The constraints can be hard or soft depending on the dataset and/or user requirements.

2.1.2. University Course Timetabling Problem (UCTP)

According to (Babaei et al., 2015), the goal of the university course timetabling problem (UCTP) is to allocate events, which include students, professors, and courses, to predefined timeslots and rooms while satisfying all constraints. These constraints encompass the availability and capacities of resources such as classrooms and their equipment. Timeslots consist of daily and weekly components, varying by institution. The challenge lies in creating a conflict-free schedule that efficiently meets the requirements of all involved parties and optimizes the use of resources.

In contrast to high schools, universities often have larger and more diverse student populations, resulting in greater complexity in timetabling. Universities may need to accommodate various degree programs, each with its own set of required courses and scheduling preferences.

Two main approaches to university course timetabling are Curriculum-based and Enrollment-based. In Curriculum-based Timetabling, courses are scheduled according to the university's curriculum, ensuring that required courses are offered at appropriate times to meet degree requirements. Enrollment-based Timetabling, on the other hand, considers individual student enrollment data to accommodate students' preferences and ensure that they can attend all required courses without scheduling conflicts.

2.1.3. University Examination Timetabling Problem (UETP)

University Examination Timetabling Problem focuses specifically on scheduling exams within a limited number of time slots while avoiding conflicts in each student's examination schedule and providing adequate preparation time between exams.

Although similar to University Course Timetabling in terms of resource allocation, Examination Timetabling emphasizes the importance of providing sufficient preparation time for students between exams. This may involve spreading exams out over a longer period to ensure that students have enough time to study and prepare effectively.

Additionally, Examination Timetabling typically involves scheduling multiple exams in a single room and ensuring that students are only required to take one exam per day to avoid overloading them with too many exams in a short period.

2.2. State-of-Art

Csima & Gotlieb (1964) made pioneering contributions to solving timetable programming challenges. Since then, numerous research efforts have expanded on these foundations, employing diverse methodologies. However, as educational systems evolve, new complexities arise, prompting the need for innovative solutions.

This subchapter aims to analyze the methodologies and models used to address educational timetabling problems. It will provide concise overviews, including objective function, approach(es), relevant parameters, variables, and resulting solutions, where possible. The goal is to determine the most suitable methodology and model for resolving the timetabling problem of the *Instituto Superior de Engenharia do Porto.*

By reviewing the evolution of various approaches and methodologies, this subchapter will highlight the progress made in addressing timetabling challenges and the ongoing search for innovative solutions to meet the demands of increasingly complex educational environments.

2.2.1. High-School Timetabling Problem (HTP)

A comprehensive review by Post, Ahmadi, Daskali et al. (2012) delved into high school timetabling problems across various countries. Their analysis distilled a collection of common constraints, which were subsequently categorized into three main groups: basic scheduling problem, constraints for the event, and constraints for resources.

Building upon this groundwork, Pillay (2014) further refined the classification, expanding it into seven distinct groups. These include problem requirement constraints, no clash constraints, resources utilization constraints, workload constraints, period distribution constraints, preference constraints, and lesson constraints. Notably, these constraints exhibit varying degrees of rigidity, with some considered hard constraints, while others are softer, contingent upon dataset intricacies or user specifications.

As elucidated in the study by Tan et al., (2021), common methodologies for resolving timetabling problems include a range of approaches:

- **Mathematical Optimization Algorithms:** These methods employ precise mathematical formulations to optimize timetabling solutions. For instance, Integer Programming ensures that variables representing events or resources are restricted to whole numbers, aiding in the creation of feasible and efficient schedules tailored to the constraints of the educational institution.
- **Meta-heuristic Algorithms:** These approaches are adept at navigating the vast solution space of timetabling problems by employing iterative search processes. They leverage techniques like simulated annealing or genetic algorithms to iteratively refine solutions, aiming to converge on acceptable schedules within a reasonable computational timeframe.
- **Graph Coloring Algorithms:** These techniques are utilized to assign time slots to events or classes, ensuring that no conflicting activities share the same slot. By representing timetabling constraints as graph edges and nodes, algorithms like the greedy coloring algorithm efficiently allocate resources and time slots while minimizing clashes.

- **Hyper-heuristic Approaches:** Hyper-heuristics automate the process of selecting and applying heuristics to solve timetabling problems. By leveraging a diverse set of predefined heuristics and a selection mechanism, these approaches dynamically adapt the choice of heuristics based on problem characteristics or search progress. This adaptive nature enhances solution quality and convergence speed.
- **Hybrid Approaches:** Hybrid methodologies integrate multiple optimization techniques or algorithms to address timetabling complexities comprehensively. For example, combining different meta-heuristic algorithms or integrating heuristic methods within mathematical optimization frameworks allows for the creation of versatile and robust scheduling solutions tailored to the specific requirements of educational institutions.

In their work, Sørensen & Dahms (2014), a new approach to solving the school timetabling problem is presented, employing a two-stage decomposition of Integer Programming (IP). This method splits the problem-solving process into two stages: Stage I and Stage II.

In Stage I, events are assigned to timeslots, aiming to minimize the overall cost. This stage ensures each event is assigned to exactly one timeslot while managing conflicts and constraints related to resource allocation. Notably, Stage I leverages Hall's theorem for the existence of matchings in bipartite graphs, enhancing its global optimality. While the original IP model for timetabling problems is notoriously hard to solve, the decomposition significantly reduces the number of variables, making it tractable for IP solvers.

Transitioning to Stage II, the solution from Stage I is used to assign events to rooms, again minimizing the cost. Constraints ensure each event is assigned to exactly one room, considering conflicts and eligibility constraints.

Implemented with Gurobi 5.0.1, the TSD approach significantly outperforms traditional models, showcasing its potential for optimizing both solution quality and computational efficiency in educational timetabling. The evaluation of the decomposition, conducted with 100 real-life problem instances from the database of the high school ERP system Lectio, demonstrates its superior performance compared to solving the original IP model in terms of both found solutions and bounds.

The paper (Al-Yakoob & Sherali, 2015) investigates the high school timetabling problem within the context of Kuwait's public educational system. Specifically, it focuses on the assignment of professors to classes and time slots. The authors initially attempted to solve the problem using a comprehensive mixed-integer programming model but encountered challenges due to its complexity and the limitations of available optimization software.

To address these challenges, they proposed a two-stage approach. The first stage (model 1) involves a two-stage modeling solution, where the initial stage determines weekly time slots for classes, followed by the assignment of professors to classes based on the predetermined time slots. The second stage (model 2) introduces an alternative mixed-integer programming formulation, which selects valid combinations of weekly schedules from a set of feasible schedules. This formulation allows for the use of a column generation solution framework, which exploits the problem's special structure to improve computational efficiency.

Both approaches produced solutions in relatively short CPU times. However, the CGH method outperformed the TSA, showcasing its superior efficiency in tackling complex timetabling problems.

This indicates that the CGH method is more effective for solving intricate scheduling challenges, making it a preferable choice for optimizing timetables.

In (Zhang et al., 2010) a novel approach for high school timetabling problems utilizes a simulated annealing (SA) heuristic with a new extended neighborhood structure. The approach consists of two phases, each employing SA with the extended neighborhood structure.

In the first phase, an initialization step sets the current solution, plateau, and temperature. The algorithm then iteratively explores neighboring solutions, accepting moves to non-improving solutions with a decreasing probability. The search progresses from one plateau to the next, investigating neighborhoods and updating solutions accordingly. This phase aims to generate a feasible timetable by satisfying hard constraints and maximizing satisfaction of soft constraints.

The second phase begins with the feasible timetable obtained from phase one and aims to further improve the timetable's quality while maintaining feasibility. Similar to phase one, it iterates through neighborhoods, exploring swaps of assignments during two time periods. The algorithm moves from one plateau to the next, adjusting temperature and exploring new solutions.

Computational results indicate the efficacy of this approach, outperforming other methods such as evolutionary algorithms and constraint programming. The new extended neighborhood structure enhances the efficiency and performance of SA in addressing high school timetabling challenges.

In Table 1, a summary of the reviewed articles is presented, highlighting the methodologies and approaches discussed in each study. Additionally, the table provides an overview of the results achieved. This summary serves to offer a clear and concise comparison of the different research efforts, illustrating the variety of methods used and their respective outcomes in addressing timetabling challenges.

Table 1 - Summary of the articles related to High School Timetabling Problem

Authors	Methods & Approaches	Results
Post, Ahmadi, Daskali et al., 2012	Comprehensive Review	Identified and categorized common constraints in high school timetabling problems
Pillay, 2014	Classification Refinement	Expanded classification into seven distinct constraint groups
Tan et al., 2021	Scientific Review	Overview of prevalent methodologies for tackling timetabling problems
Sørensen & Dahms, 2014	Two-stage Decomposition of IP	Superior performance in both solution quality and computational efficiency
Al-Yakoob & Sherali, 2015	Two-stage Approaches, Mixed-Integer Programming	CGH method outperformed TSA, showing superior efficiency in solving complex timetabling problems
Zhang et al., 2010	Simulated Annealing with Extended Neighborhood Structure	Outperformed other methods; effective in addressing high school timetabling challenges

2.2.2. University Examination Timetabling Problem

The university examination timetabling problem involves scheduling exams to optimize the use of resources and minimize conflicts. Various optimization methods have been developed to tackle this challenge.

The Hill Climbing Optimization (HCO) algorithm explores only a small portion of the search space, focusing on accepting only moves that improve the current solution. The process begins with an initial solution, and then the algorithm makes a move to generate a new one. If the new solution shows an improvement in quality, it replaces the current one (Burke & Newall, 2003).

Burke & Bykov (2008) introduced a modification to the HCO by proposing the Late Acceptance Hill Climbing method. This approach works by iteratively refining a single solution. After each move, the algorithm records the fitness values in a list of a certain size. The algorithm then compares the current solution with previous ones in the list, and a new solution is accepted based on this comparison. This research has shown that the Late Acceptance Hill Climbing method can produce high-quality results, often outperforming some of the more popular methods found in the literature.

However, this approach has certain limitations, particularly in its dependence on the list size. The performance can vary significantly depending on the dataset, as different datasets require different list size settings. The authors provided custom list sizes for each dataset, which led to competitive solutions. They also proposed a general list size setting, which can yield comparable results across similar datasets.

Leite N. et al (2019) introduced an innovative variant of the Simulated Annealing algorithm, named FastSA, which aims to optimize the process of timetabling by refining how exams are shifted within the scheduling framework. The key idea behind FastSA is that an exam is only moved to a different time slot if it had any approved shifts in the immediately preceding temperature bin—a concept central to the algorithm's design. The process is structured into ten distinct temperature bins, ensuring that an equal number of evaluations are performed within each bin, which contributes to the algorithm's efficiency.

One of the significant observations from the study is that if an exam does not experience any accepted moves in a given temperature bin, it is likely that it will have few or no accepted moves in subsequent bins. This insight helps to streamline the scheduling process, focusing computational efforts on the most promising areas of the search space.

FastSA was rigorously tested against the standard Simulated Annealing algorithm using the benchmark from the second International Timetabling Competition (ITC 2007). The results were impressive: FastSA required up to 41% fewer evaluations in one dataset and 17% fewer in another, compared to the standard approach. This reduction in computational effort did not come at the cost of solution quality; in fact, FastSA achieved the best average fitness value in four out of twelve datasets, demonstrating its competitive edge.

The impact of this research is significant for several reasons. First, it showcases the effectiveness of FastSA in tackling a highly complex, NP-Complete timetabling problem, a common challenge in educational institutions. Second, the proposed method offers a clear advantage in terms of reduced computation time, making it a valuable tool for institutions looking to optimize their scheduling processes. Finally, FastSA's ability to improve upon the best-known results in a benchmark instance when compared with other state-of-the-art methods highlights its potential for widespread application in the field of educational timetabling.

Pais & Amaral (2012) address the examination timetabling problem using a Tabu Search (TS) algorithm enhanced with a Fuzzy Inference Rule-Based System (FIRBS). The objective is to efficiently schedule exams by minimizing conflicts and balancing student and faculty needs. The TS algorithm explores the solution space iteratively, with a "tabu list" preventing the revisit of previous solutions. The key challenge is tuning the "tabu tenure," the duration a move remains in the tabu list.

To automate this tuning, the FIRBS dynamically adjusts the tabu tenure based on two factors: "Frequency" (how often a move is placed in the tabu list) and "Inactivity" (how long since the move was last blocked). This balance between intensification (focused search) and diversification (broad exploration) improves the algorithm's performance.

The initial solution is created using a "Saturation Degree" heuristic, prioritizing exams with fewer available time slots and more students. The solution is encoded as a vector, with each component representing an exam's assigned time slot.

Testing on 11 real-world timetabling problems showed that TS with FIRBS consistently outperformed or matched TS with fixed tabu tenure values. The FIRBS allowed the algorithm to dynamically adjust its search strategy, leading to better overall performance without requiring manual tuning. This methodology could also be applied to other optimization problems beyond timetabling.

In Table 2, a summary of the reviewed articles is presented, including the methodologies and approaches discussed in each study, as well as the results obtained. This table provides a clear overview of the various techniques applied to address the university examination timetabling problem and highlights the effectiveness of each method.

Table 2 - Summary of the articles related to University Examination Timetabling Problem

Authors	**Methods & Approaches**	**Results**
Burke & Newall, 2003	Hill Climbing Optimization (HCO)	Explores a small portion of the search space, accepting only improvements to the current solution.
Burke & Bykov, 2008	Late Acceptance Hill Climbing	Produces high-quality results, but performance depends on the list size, varying with datasets.
Leite et al., 2019	Fast Simulated Annealing (FastSA)	Significant reduction in evaluations and better average performance in timetabling benchmarks.
Pais & Amaral, 2012	Tabu Search with Fuzzy Inference Rule-Based System (FIRBS)	Improved performance without manual tuning, applicable to other optimization problems.

2.2.3. University Course Timetabling Problem

The university timetabling problem is complex and challenging, particularly when approached using integer programming (IP) models. In addressing this issue, (Prabodanie, 2017) proposed a novel model that aims to simplify and enhance the scheduling process. This model was implemented using the Open Solver add-in for Excel, which is known for its flexibility and computational power.

Prabodanie’s model utilized a binary integer programming approach, which significantly improved the efficiency of the scheduling process. By designing decision variables with fewer dimensions, the model was able to reduce the complexity and size of the problem, making it more manageable.

The application of this model showed promising results, indicating that computerized solutions can offer more efficient and effective scheduling compared to traditional methods. The integration of Open Solver with MS Excel proved to be highly productive. Excel's programming capabilities enabled the creation of customized variable sets, which were crucial in developing compact and effective schedules.

The performance of the model varied depending on the size of the timetabling problem. For smaller problems, schedules could be computed in just a few seconds, while larger problems required up to 30 minutes to solve. Overall, this approach demonstrated that combining sophisticated algorithms with accessible tools like Excel can lead to significant improvements in timetabling efficiency.

(Daskalaki et al., 2004) introduces a novel 0–1 integer programming (IP) formulation to tackle the university timetabling problem. The main objective lies in minimizing a linear cost function while adhering to various operational rules and requirements typically found in academic institutions. This approach capitalizes on recent advancements in IP and mixed-integer programming (MIP) techniques, facilitated by modern computer software and hardware capabilities, thus rendering it feasible to handle large-scale combinatorial problems efficiently.

In terms of approach, the focus is on minimizing the linear cost function, allowing for the consideration of preferences concerning teaching periods, days of the week, and classroom allocations. A plethora of constraints are incorporated to ensure the collision-free scheduling of courses, professors, and classrooms. Additionally, the model supports the scheduling of consecutive time periods and repeated sessions for different student groups. Notably, the IP formulation utilized in this study employs 0–1 variables, which preserve the structural elements of courses, students, professors, days, and periods. The introduction of auxiliary variables effectively manages complexities such as consecutive time slots and repetitions.

The model structure is defined by six parameters: days of the week, time periods, student groups, professors, courses, and classrooms. Two sets of binary variables are adopted - basic and auxiliary. The former represents scheduled courses, while the latter manages consecutive periods and repetitions.

Computational results highlight the efficacy of the proposed IP model. Three problems of varying sizes were successfully solved, with the number of courses ranging from 25 to 92. Optimization time ranged from 2.5 minutes to 95 minutes for different problem sizes. Model characteristics, including equations, binary variables, and non-zeros, varied across the problem instances. For larger problems, decomposition into smaller ones proved feasible, leveraging the characteristics of different student groups and classroom requirements.

The excerpt from (Daskalaki & Birbas, 2005) discusses methodologies and models for university timetabling problems, presenting an IP-based two-step relaxation method to generate efficient solutions in two stages.

The problem formulation considers various aspects such as course structures, student groups, and department-specific requirements. The IP model aims to optimize course scheduling while adhering to constraints related to mandatory and elective courses, student group formations, and resource allocation.

To address computational challenges, a two-stage relaxation procedure is proposed. In Stage I, constraints related to consecutiveness in multi-period sessions of courses are relaxed to generate an initial solution. In Stage II, these constraints are reintroduced, and the timetable is optimized on a day-by-day basis to ensure consecutiveness of sessions.

The results of the study indicate that the proposed two-stage relaxation procedure is highly efficient for solving university timetabling problems. It significantly reduces computational time without sacrificing solution quality. The method successfully produces feasible timetables that satisfy both hard and soft constraints, demonstrating its effectiveness in handling large-scale timetabling problems.

(Bagger et al., 2019) introduces a novel approach to solving the curriculum-based course timetabling problem (CCT) using integer-programming relaxation. The problem involves scheduling lectures for multiple courses within a specified time horizon while adhering to various constraints such as room assignments and curriculum requirements. The proposed model utilizes a pattern formulation, where each pattern represents a course assignment into periods on a single day. Preprocessing techniques are applied to reduce variables, and valid inequalities are derived to strengthen the model.

Computational experiments on 21 real-world data instances demonstrate the effectiveness of the proposed approach. By comparing results with existing literature, the authors show that incorporating all valid inequalities yields the best outcomes across most instances. The pattern formulation consistently outperforms other algorithms in achieving competitive lower bounds, highlighting its efficacy in addressing CCT problems.

Additionally, comparisons with previous studies and best-known lower bounds reveal significant improvements achieved by the proposed algorithm. Overall, the paper contributes a robust methodology for CCT optimization, enhancing lower bounds and advancing the field of educational timetabling.

(Alsmadi, Abo-Hammour, Abu-Al-Nadi and Algsoon, 2011) introduce a novel approach to address the university course timetabling problem, crucial for organizing lectures effectively. This problem involves scheduling meetings between professors and students while adhering to a range of constraints, from rigid rules that cannot be broken (such as ensuring instructors don't teach simultaneous classes) to softer preferences (such as instructors' preferred time slots).

The method they propose relies on genetic algorithms (GAs), which are like computerized versions of natural selection and evolution. It starts by creating a population of potential timetables, ensuring none of them violates the hard constraints. Each timetable in this population is like a blueprint, detailing which courses are taught by which instructors, at what times, and in which rooms.

Then comes the testing phase. They applied their GA approach to the Faculty of Engineering and Technology at the University of Jordan, comparing the timetables it generated with ones made manually. The results promised fewer violations of the softer preferences and less strain on the instructors. They made sure that no hard constraints were violated right from the start, unlike some previous approaches. Plus, they treated room availability as a strict rule, ensuring all courses were allocated rooms within the specified department.

(Alvarez-Valdes et al., 2002) developed a computer package named HORARIS to address the challenges of constructing university timetables. The program employs a Tabu Search (TS) algorithm to optimize the timetable construction process. Their study focused on the University of Valencia, particularly within the Business School.

Methodologically, the solution process unfolds in three phases: initialization, improvement, and refinement. In the initialization phase, the objective is to generate a set of solutions for one student. The improvement phase, the second stage, combines these solutions and applies TS with local strategies to obtain high-quality timetables. Notably, this phase excludes considering the worst solution(s) for each student. The third phase involves room allocation and improvement without altering the initial assignment of courses to timeslots. In this phase, the objective is to optimize room utilization.

The study's numerical results highlight the successful application of the HORARIS program at the University of Valencia, specifically within the Business School. The institution's scheduling complexities underscore the necessity for tailored solutions, where requirements such as accommodating optional courses and minimizing simultaneity conflicts are factored into the problem formulation.

(Yang & Jat, 2011) provides a comprehensive and detailed exploration of the University Course Timetabling Problem (UCTP) and proposes an innovative solution using genetic algorithms (GAs) with guided search and local search (LS) strategies. The UCTP is depicted as a combinatorial optimization problem due to its NP-hard nature, necessitating a complex approach for efficiently allocating events to schedules and suitable rooms.

A significant contribution of the study is the introduction of the guided search strategy, which utilizes information from successful individuals in previous generations to influence offspring creation, while local search techniques are employed to enhance search efficiency and individual solution quality. The guided search strategy employs a data structure to create children, storing information extracted from successful individuals in previous generations. Additionally, the local search technique, applied within the GAs framework, aims to improve the quality of individuals by searching in three neighboring structures. This consolidation of local search within GAs results in the development of the Enhanced Guided Search Genetic Algorithm (EGSGA), aiming to maximize allocations and minimize the violation of soft constraints.

The problem formulation is carefully delineated, emphasizing the assignment of events, students, and rooms within the parameters of the various constraints. The use of matrices to represent the relationships between students and events, event conflicts, room characteristics, and event requirements provides a clear and organized structure for problem representation and solution.

The conducted comparative experiments convincingly demonstrate the effectiveness of the proposed EGSGA algorithm compared to other methods across a variety of problem instances. The EGSGA consistently exhibits superior performance, yielding optimal or near-optimal solutions across different problem scenarios.

In a study conducted by (Rappos et al., 2022), the researchers developed an algorithm aimed at finding a feasible solution to the challenging problem of assigning class times. The approach involves a two-step process: an initial optimization phase followed by a local search method designed to enhance the quality of the solution.

The formulation of this problem relies on four key decision variables: x, z, y, and z. These variables are crucial as they represent different components of the assignment process, including the allocation of classrooms and the scheduling of classes. The primary objective of the algorithm is to minimize the total time required for the assignment while also adhering to various constraints, such as ensuring an even distribution of classes and the appropriate allocation of classrooms.

To achieve this, the researchers employed a combination of mixed-integer programming (MIP) and linear programming models. The algorithm was implemented using programming languages and tools such as Java, CPLEX, and Gurobi. The computational tasks were carried out on virtual machines equipped with 32GB of RAM and four processing cores, providing the necessary computational power to handle the problem.

Once a feasible solution was identified, the algorithm applied an improvement heuristic. This iterative process aimed to refine the initial solution, gradually improving its quality and effectiveness. The method proved to be highly effective for small and medium-sized problems, where it could deliver results efficiently. However, the algorithm faced challenges when applied to larger problems, where its performance was less optimal.

On average, the first stage of the optimization process was completed within approximately one hour. In around 70% of the cases, the entire process, including the improvement phase, was completed in under two hours, demonstrating the algorithm's efficiency in handling smaller-scale timetabling challenges.

In a study by Rudová & Murray (2002), the authors detail the development of a timetabling system specifically designed for Purdue University, which manages the course schedules for nearly 30,000 students. The paper explores the application of a logic programming extension that adapts to the constraints used in the timetabling system, allowing for the partial fulfillment of soft constraints.

The approach utilized a weighted Constraint Satisfaction Problem (CSP) model, aiming to minimize the overall dissatisfaction with the constraints by considering the varying weights and costs associated with each one. The system currently addresses three types of soft constraints: two categories of unary constraints related to faculty preferences, and a set of binary constraints. To enhance the system's cost function, a branch-and-bound search method was implemented. This search process improved the solution through four stages of repair searches; however, further efforts did not yield additional improvements.

Overall, the system successfully met 94% of the students' scheduling needs and accommodated 90% of the faculty's preferences. Despite these achievements, the system faced challenges with the ILOG Scheduler's bound consistency algorithms. A significant issue arose with room availability, as classes were frequently scheduled at times when there were not enough rooms available to accommodate them.

(Inês M, 2023) work focused on developing an algorithm to assist in the creation of academic timetables at *Instituto Superior de Engenharia do Porto* (ISEP). The proposed solution utilized an integer programming approach to address various constraints and preferences of both faculty and students, aiming to streamline and optimize the timetable creation process.

The research involved the development of an algorithm using Python and the Pyomo library, offering a flexible and efficient approach to resource allocation. This algorithm was designed to adapt to evolving needs, ensuring that future demands could be easily accommodated while significantly reducing the time and resources required for timetable creation.

The algorithm effectively scheduled 128 one-hour classes throughout the week. It primarily allocated classes to the first two periods of the day, with higher concentrations on Tuesdays and Fridays. While this approach improved overall scheduling efficiency, it also highlighted the need for a more balanced distribution across the week. Although the algorithm avoided overlaps and ensured that multi-period classes were scheduled consecutively, the distribution of classes was somewhat uneven. Future improvements could focus on better balancing class timings and integrating fixed scheduling constraints for specific professors to align more closely with institutional needs.

Additionally, the algorithm did not fully account for faculty and student preferences, suggesting that future research could benefit from incorporating these preferences to further refine the scheduling process.

Overall, the thesis presented a practical solution for timetable creation, demonstrating a significant reduction in time and resource expenditure compared to manual methods. The results and identified areas for improvement offer valuable insights for advancing timetable optimization and addressing key challenges in the scheduling process.

Table 3 presents a comprehensive summary of the reviewed articles, outlining the methodologies and approaches explored in each study. It also highlights the results achieved by these methods.

Table 3 - Summary of the articles related to University Course Timetabling Problem

Authors	Methods & Approaches	Results
Daskalaki et al. (2004)	0–1 Integer Programming (IP)	Efficient solution for problems of various sizes; optimization times from 2.5 to 95 minutes.
Daskalaki & Birbas (2005)	Two-stage relaxation method	Reduced computational time; feasible timetables.
Bagger et al. (2019)	Pattern-based IP relaxation	Improved lower bounds; effective pattern formulation.
Alsmadi et al. (2011)	Genetic Algorithms (GAs)	Reduced soft preference violations; more efficient than manual methods.
Alvarez-Valdes et al. (2002)	Tabu Search (TS)	Improved room allocation; minimized conflicts.
Yang & Jat (2011)	Enhanced Genetic Algorithm (EGSGA)	Optimal or near-optimal solutions.
Rappos et al. (2022)	Mixed-Integer Programming (MIP)	Effective for small/medium problems; less optimal for larger ones.
Rudová & Murray (2002)	Weighted CSP	High satisfaction for students and faculty; issues with room availability.
Prabodanie (2017)	Binary Integer Programming	Efficient scheduling; quick solutions for small problems, up to 30 minutes for larger problems.
Inês M, (2023)	Integer Programming	Efficient scheduling. Needs better balance and preference integration.

2.3. Critical Analysis

When comparing the three types of timetabling problems, the High School Timetabling Problem tends to be simpler and less complex than university-level problems. This simplicity arises from the fewer variables involved in high school settings, such as classes and professors, and the generally straightforward preferences that need to be accommodated. Studies indicate that viable solutions for high school timetable can often be achieved in just a few minutes, especially with a two-stage approach where the first stage resolves initial conflicts, and the second stage refines the solution.

Conversely, University Course Timetabling and University Examination Timetabling problems are considerably more complex. These problems involve multiple variables including professor availability, classroom allocation, and specific time preferences. As a result, solving them typically requires more sophisticated methods such as genetic algorithms, local search techniques, and integer programming. This increased complexity results in longer computation times, which can vary from minutes to several hours depending on the size of the problem and the approach used.

Given this context, the model proposed by Daskalaki et al. (2004) was selected as the basis for adapting the scheduling system at *Instituto Superior de Engenharia do Porto* (ISEP). This choice was driven by several factors. First, the Daskalaki model utilizes a 0-1 integer programming formulation that aligns well with the complexities and characteristics of ISEP's scheduling needs. The use of binary variables simplifies the modeling of multiple classes, professors, rooms, and course units, making it suitable for ISEP's requirements.

Second, the model's structure reduces complexity by using auxiliary variables to manage consecutive periods and repeated sessions, which are essential for effective timetable creation at ISEP. This approach helps keep the problem computationally tractable, avoiding excessive complexity despite the numerous elements involved.

Third, the effectiveness of the Daskalaki model is supported by its proven results. The model has demonstrated success in solving problems of various sizes, with optimization times ranging from minutes to slightly over an hour, depending on the problem scale. This performance indicates that the model can be adapted to ISEP with reasonable expectations of achieving viable solutions within a suitable timeframe.

While the Daskalaki model was chosen for its suitability and flexibility in addressing timetable creation challenges, the work of Inês M, (2023) provided a valuable foundation. The existing research offered a solid base and insights that informed the adaptation of the Daskalaki model, ensuring that the final algorithm effectively addresses the specific needs and constraints of ISEP.

Consequently, the model proposed by (Daskalaki et al., 2004) follows an integer programming formulation and shares the following general features with DEM:

- I as day of the week.
- J as period of the day, on which classes might be scheduled, single classes not considering the repetition of periods.
- K as group of students, for which a course in the timetabling is designed.
- L as professor, lecturer or other teaching staff of the faculty.
- M as courses to be scheduled for a given set of groups of students of each degree.
- N as classrooms available for scheduling courses for a given set of groups of students.

Based on the six sets above, many subsets were created to reduce the number of variables, keeping them controllable:

- K_l – group of students for which professor *l* offers some course.
- L_i – professor available on day *i*.
- L_k – professor teaching at least one course for the group of students *k*.
- L_m – professor teaching course *m*.
- L_{km} – intersection between L_k and L_m (faculty mebers available that teach one course at least one group of students).
- L_{ki} – intersection between L_k and L_i (faculty members available on one day to teach to a group of students).
- M_k – course designed for the kth group of students or offered by the kth division for its students.
- M_l – course taught by professor *l*.
- M_n – course designed for a group of students that fits in classroom *n*.
- M_{kl} – intersection between M_k and M_l (courses taught by faculty member *l* to a given group of students).
- M_{kn} – intersection between M_k and M_n (courses taught to a given group of students k in a classroom *n*).
- M_{kln} – intersection between M_k, M_l and M_n (courses taught to a group of students *k* at classrooms *n*, by a professor *l*).
- M_{lab} – courses *m* that require lab work.
- N_{mk} – classroom *n* that fits the group of students *k* for the course *m*.
- I_n – day *i* on which classroom *n* is available for use.
- I_l – day *i* on which professor *l* is available for teaching assignment.
- I_{ln} – intersection between I_l and I_n (days on which at least one professor *l* is available to teach at classroom *n*).
- J_{iln} – period *j* of day *l* on which professor *l* and classroom *n* are available for assignments.
- JL_{iln} – time interval from period j_a to j_b of day *i* on which professor *l* and classroom *n* are available for assignments.
- P_m – used for multi-period classes (more than the usual 50minutes/1hour). $P_m = p_v \in \{1,2,\dots,pmax_m\}$, where $pmax_m$ is the number of repetitions of 1-hour sessions that a given course m requires.
- H_m – used for multi-period classes (more than the usual 50minutes/1hour).
- *PRA* – only to be used in case there are pre-assigned constraints.

To address the problem, the authors introduced two different sets of binary variables. The first set, known as the basic set of variables, serves as the primary set. The second set, referred to as auxiliary variables, is used to support the main set.

- $x_{i,j,k,l,m,n}$ - takes the value of 1, when course m, taught by professor l to the group of students k, is scheduled for the jth period of day i in classroom n.
- $y_{i,p_v,h,h_{v,m,n}}$ - takes the value of 1, when course m, which requires a session of hv consecutive periods, is scheduled for day i for the group of students k in classroom n.

The following sections present the constraints established in the model, organized into five groups.

The first group, which includes the initial three constraints, consists of **uniqueness constraints** that ensure there are no conflicts in the timetable.

- Ensures that every member of the teaching staff shall be assigned at most one course, one group of students and one classroom at a time:

$$\sum_{k \in K} \sum_{m \in M_{kl}} \sum_{n \in N_{mk}} x_{i,j,k,l,m,n} \leq 1, \forall i \in I, \forall j \in J, \forall l \in L_i \quad (1)$$

- Ensures that for every group of students at most one course *m*, one teaching person *l* and one classroom *n* shall be assigned to every teaching period *j*.

$$\sum_{l \in L_{ki}} \sum_{m \in M_{kl}} \sum_{n \in N_{mk}} x_{i,j,k,l,m,n} \leq 1, \forall k \in K, \forall i \in I, \forall j \in J \quad (2)$$

- Assures that every classroom may be assigned to at most one course, one professor, and one group of students at a time:

$$\sum_{k \in N} \sum_{l \in L_{ki}} \sum_{m \in M_{kln}} x_{i,j,k,l,m,n} \leq 1, \forall n \in N, \forall i \in I_n, \forall j \in J_{in} \quad (3)$$

The second set of constraints, which includes constraints (4), (5) and (6), represents the**completeness constraints.** This set of constraints ensures that the timetable is complete.

- Ensures that all courses in the curriculum of each student year should be in the timetable and in the right amount of teaching periods (a_k):

$$\sum_{l \in L_k} \sum_{m \in M_{kl}} \sum_{n \in N_{mk}} \sum_{i \in I_{ln}} \sum_{j \in J_{iln}} x_{i,j,k,l,m,n} = a_k, \forall k \in K \quad (4)$$

- Assures that each course should be scheduled for as many teaching periods as the curriculum of each group of students requires (b_m):

$$\sum_{n \in N_{mk}} \sum_{i \in I_{ln}} \sum_{j \in J_{iln}} x_{i,j,k,l,m,n} = b_m, \forall k \in K, \forall l \in L_k, \forall m \in M_{kl} \quad (5)$$

- Guarantees that each person in the teaching staff should be assigned to so many teaching periods as his/her weekly teaching load require (s_l):

$$\sum_{k \in K} \sum_{m \in M_{kl}} \sum_{n \in N_{mk}} \sum_{i \in I_{ln}} \sum_{j \in J_{iln}} x_{i,j,k,l,m,n} = s_l, \forall l \in L \quad (6)$$

The third set of constraints, known as **consecutiveness constraints**, includes constraints (7), (8), and (9). This set of constraints aims to ensure that the timetable can accommodate requests for multi-period sessions in some courses.

- Ensures that a course m requiring a session of h_v consecutive periods should be assigned exactly h_v periods on a given day:

$$\sum_{j \in JL_{iln}} x_{i,j,k,l,m,n} - \sum_{h_v \in H_m} \sum_{p_v \in P_m} \left(y_{i,p_v,k,h_v,m,n} * h_v\right) = 0, \quad (7)$$
$$\forall i \in I, \forall k \in K, \forall l \in L_k, \forall m \in M_{kl}, \forall n \in N_{mk}$$

- The equations (8) e (9) ensures that if h_v periods of a given day have been assigned to course m, they should also be consecutive:

$$\forall i \in I, \forall k \in K, \forall l \in L_{ki}, \forall m \in M_{kl}, \forall n \in N_{mk},, \forall j_a \in FJL_{iln},, \forall h_v \in H_m \wedge$$
$$h_v > 1, \forall t \in \{1, \dots, h_v - 1\}, x_{i,j_a,k,l,m,n} - x_{i,j_a+t,k,l,m,n} \le 0 \quad (8)$$

$$\forall i \in I, \forall k \in K, \forall l \in L_{ki}, \forall m \in M_{kl}, \forall n \in N_{mk},, \forall j \in J_{iln},, \forall h_v \in H_m \wedge$$
$$h_v > 1, \forall t \in \{2, \dots, h_v\} - x_{i,j,k,l,m,n} + x_{i,j+1,k,l,m,n} - x_{i,j+t,k,l,m,n} \le 0 \quad (9)$$

The fourth set of constraints is referred to as repetitiveness constraints. This set of constraints is also connected to the concept of consecutiveness in that it ensures the correct number of sessions of a particular type and the proper number of repetitions for a given session, in cases of repetitive recitations or lab work. Here, b_{m,h_v}represents the total number of h_v- period sessions required for course m within a week.

- The equation (10) refers to courses that require non-repetitive sessions, that is lectures or recitations that are delivered just once to their audience:

$$\sum_{i \in l_n} \sum_{p_v \in P_m} y_{i,p_v,k,h_v,m,n} = b_{m,h_v}, \forall k \in K, \forall m \in M_k - M_{lab,} \forall h_v \in H_m, \forall n \in N_{mk}, \quad (10)$$

- On the other hand, the equation (11) additionally secures the existence of at most one of these sessions per day:

$$\sum_{h_v \in H_m} \sum_{p_v \in P_m} y_{i,p_v,k,h_v,m,n} \le 1, \quad (11)$$
$$\forall k \in K, \forall m \in M_k - M_{lab,} \forall l \in L_{km}, \forall h_v \in H_m, \forall n \in N_{mk}, \forall i \in I$$

- In case of repetitive parts of courses, like the lab work for a given course, the scheduling of the h_v period sessions does not require different days for different sessions, since each session is delivered to a different sub-group of the kth group of students and the previous two constraints are replaced by equation (12), where $pmax_m$ is the number of students sub-groups and therefore the number of repetitions required for the h_v period sessions of course m.

$$\sum_{n \in N_{mk}} \sum_{i \in I_{ln}} \sum_{p_v \in P_m} y_{i,p_v,k,h_v,m,n} = pmax_m, \forall k \in K, \forall m \in M_{lab}, \forall h_v \in H_m \quad (12)$$

Finally, there is the set of constraints known as pre-assignment constraints. These constraints ensure that certain courses are assigned to specific periods on specific days. They can be used either for the exact pre-allocation of courses or to facilitate and better manage computational difficulties.

- Ensures that a course *m* taught by professor *l* to student group *k* should be assigned to a given period in a given day:

$$x_{i,j,k,l,m,n} = 1, \forall (i,j,k,l,m,n) \in PRA \tag{13}$$

As can be seen in equation (14), the objective is to minimize a cost function consisting of two terms. The first term of the objective function refers to the cost of assigning course *m* to the *jth* period of day *i*, while the second term refers to the cost incurred from the assignment of those courses that require sessions of more than one consecutive hour, on a given day of the week.

$$minimize \left\{ \sum_{k\in K} \sum_{l\in L_k} \sum_{m\in M_{kl}} \sum_{n\in N_{mk}} \sum_{i\in I_{ln}} \sum_{j\in J_{iln}} c_{i,j,k,l,m,n} * x_{i,j,k,l,m,n} + \sum_{k\in K} \sum_{i\in I} \sum_{m\in M_k} \sum_{n\in N_{mk}} \sum_{h\in H_m} \sum_{p_v\in P_m} a_{i,p_v,k,h_v,m,n} * y_{i,p_v,k,h_v,m,n} \right\} \tag{14}$$

3. METHODS AND APPLICATIONS

This section shifts from theoretical exploration to practical application, connecting the literature review to real-world implementation. It begins with a succinct overview of the Department of Mechanical Engineering (DEM) and its unique context, establishing the foundation for the adapted model that follows. The modified model is then introduced, with a focus on the key adjustments made to suit the specific needs of the case study. Additionally, the datasets used to validate the model are outlined, along with a detailed explanation of the computational framework, which integrates Python, Pyomo, and Microsoft Office Excel. This approach ensures that the theoretical insights gained are directly applied to the real-world setting of the DEM, reinforcing the relevance and applicability of the research.

3.1. Problem Framing

The current project aims to implement a scheduling algorithm to support the creation of university timetables within the Mechanical Engineering Department (DEM). To ensure that this algorithm meets the department's needs, it is essential to understand certain parameters associated with the department.

Course-based timetables are created twice a year, before the beginning of each semester. Several problems can arise when creating timetables manually:

- Creating timetables manually can be a time-consuming process, often taking several days to complete by a faculty team.
- The quality of the timetables may be affected by tight deadlines and the varying experience of those involved in timetable creation.
- The outcome is significantly influenced by the initial method used for creating the timetables.
- Each school has different constraints, making it difficult to apply a general algorithm.
- Inefficient allocation of rooms and resources can lead to underused spaces and scheduling conflicts.
- There is an increased risk of mistakes, such as overlapping classes or incorrect course assignments.
- Adjusting schedules to accommodate unexpected changes or faculty availability can be challenging.
- It can be difficult to accommodate professors' preferred teaching times.
- Poor communication between departments can result in conflicting or poorly distributed schedules.
- As the university grows, manual processes become increasingly unsustainable.

The DEM comprises more than 2000 students, offering 3 bachelor’s degrees, 5 master's degrees, and 18 postgraduate degrees. Over 100 faculty members are involved in teaching these programs. It is noteworthy that each program follows a semester-based curriculum structure, with student cohorts organized by course and faculty allocation.

Each semester, the created timetables must provide specific and indispensable information, including:

- Course name
- Subject
- Name of the professor
- Class type
- Classroom
- Day of the week
- Period of the day

The creation of timetables at ISEP is a manual process, based on some rules/definitions and the schedules of previous years, such as:

- Each degree consists of multiple courses, which are taught based on predefined hours and class types outlined in the course syllabus.
- Each course is designated as either semester-long or year-long and is assigned to a specific year within the degree program.
- All students within a particular group attend the same degree program, courses, and classes, scheduled at designated time slots.
- The allocation of student groups and faculty members to courses is predetermined (e.g., group 1NA of LEM attends ALGAN taught by MGM).
- A weekly plan is established for each course, specifying the types of classes (e.g., ALGAN comprises 2 hours of theoretical class and 2 hours of theoretical-practical class).
- Theoretical (T) classes may be taught by more than one faculty member.
- The classes for 1st and 3rd-year undergraduate courses are held during the morning periods, while the classes for 2nd-year courses are scheduled in the afternoons.
- Availability of department classrooms is generally not restricted.

Also, there are some pre-assignments defined, such as the number of students enrolled in each course are considered to divide them into several groups of students (Table 4).

Table 4 - Distribution of students into several groups for each course

Degree	**Course**	**Type**	**Hours**	**Prof**	**A**	**B**	**C**	**D**	**E**
LEMA	ALGEB	T	2	ATM	1	1	1	1	1
LEMA	ALGEB	TP	2	ATM	1	1			
LEMA	ALGEB	TP	2	ATM			1	1	1
LEMA	APROG	T	1	ARF	1	1	1	1	1
LEMA	APROG	PL	2	ARF	1				
LEMA	APROG	PL	2	ARF		1			
LEMA	APROG	PL	2	ARF			1		
LEMA	APROG	PL	2	ARF				1	1
LEMA	CMATE	T	1	RBC	1	1	1	1	1

Each type of class has a maximum allowed number of students. For example, in theoretical classes, a maximum of 100 students is permitted, meaning that a course with more than 100 students will need to be divided into 2 groups.

Subsequently, each faculty member is assigned to their respective courses, detailing the number of each type of class each professor will teach. The following table illustrates how the professors' assignments were made. For example, as we can see on Table 5, Professor MGM teaches one TP class and one T class for the course ALGAN in the evening. Meanwhile, Professor DPP teaches two PL classes for the course APROG, also in the evening.

Table 5 - Distribution of classes for each course according to each professor.

Course	Professor	Program	Num T	Num TP	Num PL
ALGAN	MGM	Evening	1	1	
ALGAN	GCV	Evening		1	
APROG	JSM	Evening	1		
APROG	DPP	Evening			2

Additionally, considering the characteristics of each room and the specific requirements of each class, each classroom is assigned a type based on its capacity and features.

Also, considering the characteristics of each room and the specific needs of each class, each classroom is attributed a type, according to its capacity and features. Table 6 is an extract of the real data information to illustrate.

Table 6 - Designation of each class and its capacity.

Classroom	Type_Classroom	Capacity	Type_Class
F202	Regular	32	TP
F203	Regular	32	TP
F204	Regular	50	TP
F214	Lab	24	PL
F216	Lab	24	PL
F218	Lab	24	PL
F341	Amphitheatre	98	T
F342	Amphitheatre	104	T
I201	Amphitheatre	110	T

3.2. Mathematical model adapted to DEM-ISEP.

The adaptation of the mathematical model that serves as the basis for this project is essential to address the specific constraints, variables, and conditions presented by DEM-ISEP in the development of university timetables. The original model, as outlined in the reference article, significantly diverges from the operational realities of DEM-ISEP, particularly regarding class management, types of classes, and internal organization.

In the reference model, there is no concept of "class groups," as the curricular units (UC) are taught simultaneously to all students, except for certain laboratory sessions that are repeated for independent groups. Additionally, the reference model does not organize class groups based on the type of class or UC. Its objective function is also more straightforward, focusing primarily on preferences for days, time slots, and classrooms, without considering additional factors such as specific professors' and students' preferences.

In adapting the mathematical model, the work conducted by in her master's thesis titled " *An algorithm to support the creation of timetables in ISEP-DEM*" was also taken into consideration. Her model successfully implemented constraints related to uniqueness, consecutiveness, and overlap, which are essential for the appropriate allocation of classes and for preventing conflicts between professors and classrooms. However, it is important to note that Inês's approach was limited to a small number of courses within the first year of the Mechanical Engineering degree. As a result, the model she developed lacks the flexibility needed for application across all degrees, years, and scheduling regimes. Furthermore, the objective function was developed considering only the preferences regarding the days of the week for class allocation, which limits its ability to accommodate the department's diverse preferences.

This subchapter will further explain the specific adaptations made to the mathematical model, highlighting the new parameters introduced and the reasons behind these changes to meet the unique needs of DEM-ISEP.

3.2.1. General features for the IP Model

To ensure alignment with departmental objectives, certain parameters were retained from Inês's project while additional parameters were introduced. Specifically, parameters *I, J, K, L, M,* and *N* were maintained, with the addition of parameter *T* to account for the type of class:

- *I* is the set of all days possible for scheduling (from Monday to Friday).
- *J* is the set of all time periods in each day available for scheduling.
- *K* is the set of all DEM degrees that may be used for a given timetable.
- *L* is the set of all the professors available to teach.
- *M* is the set of courses.
- *N* is the set of classrooms available.
- *T* is the set of types of classes (T, TP, PL).

The parameter *T* was introduced to align with the department's need for the scheduling of classes based on their type. This enables lectures to be grouped specifically in the morning or afternoon and simplifies the assignment of classes to particular time slots depending on their nature. For instance, in certain cases, it may be preferable to schedule theoretical classes before theoretical-practical and laboratory-practical sessions.

The model was adapted also by incorporating new parameters based on the main ones, considering the available data to test the model and to simplify the process of fitting the constraints. Various combinations of these parameters were tested to adjust the model effectively.

In this approach, each professor is assigned specifically to their course and to the appropriate classrooms designated for that type of class. For instance, if Professor MGM is scheduled to teach the course ALGAN, he cannot be assigned to teach any other course in the same period time.

To organize this, "blocks" were established for student groups. Each block includes only one professor and one course. Each block represents a one-hour time slot in the timetable. During each hour, parameters are set based on possible combinations of assignments.

The variables that can be adjusted are the day, the time of day, and the available classrooms for the class. Classrooms are pre-selected based on the type of class for that block, whether it is T, TP, or PL, as mentioned earlier.

Considering that the information is aggregated by *k*, the parameters were defined according to this logic. This means that for any given value of the other parameters (such as classrooms, professors, course, type of class), the value of *k* is unique for each combination. Consequently, the following parameters are defined:

- I_k – day *i* available for degree/year/semester/regime *k*.
- J_k – time period *j* available for degree/year/semester/regime *k*.
- J_{ki} – time period *j* of the day *i* available for degree/year/semester/regime *k*.
- L_k – faculty member of degree/year/semester/regime *k*.
- L_{km} – faculty member of degree/year/semester/regime *k,* teaching course *m*.
- L_{kmt} – faculty member of degree/year/semester/regime *k*, teaching a class of type *t* for course *m*.
- K_l – set of degree/year/semester/regime for which professor *l* offers some course (for example, professor 'ABC' can teach more than one degree).
- M_k – courses of degree/year/semester/regime *k*.
- M_{kl} – courses of degree/year/semester/regime *k*, taught by professor *l*
- M_{kn} – courses of degree/year/semester/regime *k*, taught in classroom *n.*
- T_{km} – type of classes for course *m* of degree/year/semester/regime *k*
- T_{kml} – type of classes for course *m* taught by professor *l* of degree/year/semester/regime *k*
- T_{kmn} – type of classes for course *m* of degree/year/semester/regime *k*, taught in classroom *n*
- N_k– classroom *n* that fits for degree/year/semester/regime *k*
- N_{kt} – classroom *n* that fits for the type of class *t* of degree *k*/year/semester/regime
- N_{kmt}– classroom *n* that fits for the type of class *t* for course *m* of degree/year/semester/regime *k*.
- c_{kmlt} – number of classes (repetitions) of type *t* for course *m* of degree/year/semester/regime *k*, taught by professor *l*.
- p_{ki} – periods available for degree/year/semester/regime *k* on day *i*.
- h_{kmt} – duration (hours) for the type of class *t* for course *m* of degree/year/semester/regime *k*.

A main set of binary variables is utilized, represented by $x_{i,j,k,l,m,t,n}$, *w*hich includes the newly added general parameter *t*. Additionally, an auxiliary binary variable with the same indices, $y_{i,j,k,m,l,t,n}$ is employed to enforce the completeness and consecutiveness constraints.

The variable $z_{i,l}$ is an additional binary variable introduced to monitor the number of days each professor *l* teaches.

To demonstrate how the adapted model variables were created, consider the following example. Suppose professor 'ABC' is assigned to teach two lab ('PL') sessions of the course 'VWXYZ'. If the variable x[*i*=0, *j*=0, *k*=11, *m*= 'VWXYZ', *l*='ABC', *t*='PL', *n*='F101'] is equal to 1, this indicates that on Monday (*i*=0) at 8 a.m. (*j*=0), professor 'ABC' is teaching a one-hour block of the lab ('PL') sessions for the course 'VWXYZ' of degree/year/semester/regime 11,in room 'F101'. This variable corresponds to a specific one-hour time slot.

3.2.2. Hard constraints for the IP model

As noted in previous subchapters, the current model retains some hard constraints from Inês's work, including uniqueness, completeness, and consecutiveness constraints.

However, significant contributions were made through the development of additional constraints tailored to enhance the model's functionality. Specifically, new restrictions were introduced to optimize time slot management and to monitor the days assigned to each professor Moreover, the overlapping constraint was adapted to account for various degrees, years, and regimes, providing a more comprehensive scheduling framework.

The following equations outline the specific hard constraints implemented in the model:

- Ensures that all classes of all courses in the curriculum should be in the timetable and in the right amount of teaching periods c_{kmlt}:

$$\sum_{i \in I_k} \sum_{l \in L_{km}} \sum_{j \in J_{kl}} \sum_{n \in N_{kmt}} x_{i,j,k,l,m,t,n} = c_{kmlt} \ \forall k \in K, \forall m \in \ M_k, \forall t \in T_{km} \qquad (15)$$

- The equation (16) ensures that if a professor is scheduled to teach any class on a particular day, then the binary variable $z_{i,l}$ will be set to 1. Conversely, if the professor is not scheduled to teach on that day, $z_{i,l}$ will be 0.

$$\sum_{k \in K_l} \sum_{j \in J_k} \sum_{m \in M_{kl}} \sum_{t \in T_{kml}} \sum_{n \in N_{kmt}} x_{i,j,k,l,m,t,n} \leq |\, J \,| * \ z_{i,l}, \forall i \in I, \forall l \in L \qquad (16)$$

- The equation (17) ensures the uniqueness for each professor, i.e., every professor is assigned at most to on course, one class and classroom, on a given period of the day of a given day:

$$\sum_{k \in K_l} \sum_{m \in M_{kl}} \sum_{t \in T_{km}} \sum_{n \in N_{kt}} x_{i,j,k,l,m,t,n} \leq 1 \ \forall i \in I, \forall j \in J, \forall l \in L \qquad (17)$$

- This equation (18) guarantees that every classroom may be assigned at most one course, one professor on a given period of the day of a given day:

$$\sum_{k \in N_k} \sum_{l \ \in \ L_k} \sum_{m \ \in \ M_{kl}} \sum_{t \ \in \ T_{kml}} x_{i,j,k,l,m,t,n} \leq 1, \forall i \in I, \forall j \in J, \forall n \in N \qquad (18)$$

- Considering the structure of the parameters created, the original set of completeness constraints was adapted, and the equations were merged due to the redundancy, obtaining equations (19) and (20), that ensure simultaneously the development of the timetables considering both the right amount of teaching periods for each group of students and the required teaching periods for each course. The first equation of this set guarantees that each class of one hour is scheduled only one time. On equation (19), the auxiliary variable combined with the consecutiveness constraint – equation (20), ensures that each class that needs more than one teaching period, is present in the timetable in the right amount (h_{kmt}).

$$\sum_{i \ \in I_k} \sum_{n \ \in \ N_{kmt}} \sum_{j=1}^{j=p_{ki}-h_{kmt}+1} y_{i,j,k,l,m,t,n} \leq 1, \forall k \in K, \forall m \in M_k, \forall t \in T_{km} \qquad (19)$$

- To ensure that multiperiod classes (classes with more than one hour) are consecutive, i.e., in periods of the day with no break between them, equation (20) was adapted:

$$\sum_{j_v=j}^{j+h_{kmt}} x_{i,j,k,l,m,t,n} \geq h_{kmt} * \ y_{i,j,k,l,m,t,n} \tag{20}$$
$$\forall k \in K, \forall i \in I_k, \forall m \in M_k, \forall l \in L_{km}, \forall t \in T_{kml}, \forall n \in N_{kmt}, \forall j \in J_{ki} \ \wedge \ j \leq p_{ki} - h_{kmt}$$

A constraint was also added to prevent the overlapping of classes, ensuring that the same class group does not take different classes simultaneously. For example, in the case of ALGAN, the service distribution indicates that there is one theoretical (T) class for two practical (TP) classes. None of these TP classes can be scheduled at the same time as the T class, as defined by Equation 20.

The process begins by iterating through the blocks of classes, checking if they belong to the same year, regime, and course. If classes related to the same discipline are identified, the code checks for any hierarchical conflicts between the groups. If a conflict is found, a constraint is added to the optimization model to ensure that these classes do not occur simultaneously.

- C_k - classes of degree/year/semester/regime *k* which aggregate groups of students of other types of classes of the same course, year and program.

  $$C_{LEM,1,1,Diurno} = \{(ALGAN, MGM, T, 1), (APROG, JSM, T, 1), \ldots, (IENG1, LMD, T, 1)\}$$

- S_{kmlt} - classes with a hierarchical relation with class of course *m* of type *t* taught by professor *l* of degree *k*.

$$S_{11,ALGAN,MGM,T} = \{(ALGAN, MGM, TP, 1), (ALGAN, MGM, TP, 2), \ldots, (ALGAN, SMA, TP, 2)\}$$

$$\sum_{n \in N_{kt}} \sum_{j=1}^{j=p_{ki} - h_{kmt}+1} y_{i,j,k,l,m,t,n} + \sum_{(kr,mr,lr,tr) \in S_{kmlt}} \sum_{n \in N_{krtr}} \sum_{j=1}^{j=p_{ki} - h_{kmt}+1} y_{i,j,kr,mr,lr,tr,n} \leq 1, \tag{21}$$
$$\forall (k, m, l, t) \in C_k, \forall i \ \in I_k$$

3.2.3. Objective function for the IP model

The constraints just presented, when placed in an integer programming model, can return feasible solutions, i.e., assignments that do not violate any of basic rules. However, certain assignments are preferable than others and the improvement of the suggested solutions is the responsibility of the multiobjective function, which in this model is defined to be the following:

$$minimize \left\{ \sum_{k \in K} \sum_{l \in L_k} \sum_{m \in M_{kl}} \sum_{n \in N_{mk}} \sum_{i \in I_{ln}} \sum_{j \in J_{iln}} [(w_1 c_{i,j,k} + w_2 a_i + w_3 b_{i,j,l}) * x_{i,j,k,m,l,t,n}] + w_4 \sum_{l \in L_k} \sum_{i \in I_k} d_l * z_{i,l} \right\} \tag{21}$$

In the multiobjective function, the aim is to minimize a cost function composed of four components. The first component relates to the cost of scheduling a specific type of class for a course at a given time slot. The second component accounts for the cost of scheduling courses across different days of the week. The third component reflects the professors' preferences for teaching during specific periods on specific days, while the final component addresses their preference to teach on the fewest possible number of days.

In this model, the weights (w_1, w_2, w_3, w_4) are used by the decision maker to tune the solutions to. decision maker desired timetabling preferences.

- Assignment of values to $c_{i,j,k,m,t}$ coefficients according to departmental preferences for allocating a specific class type *t* of a certain course *m* of a certain degree/year/semester/regime *k* to a particular period *j* of the day *i*.

The values assigned to these coefficients are derived from the departmental preferences for scheduling specific types of classes during the day. For instance, the department may prefer that lectures (T) are scheduled before theory-practical sessions (TP), and these, in turn, should be scheduled before practical classes (PL).

Moreover, there is a general preference for scheduling classes earlier in the day. To reflect these preferences, penalty values ranging from 0 to 5 are assigned, with lower values indicating higher preference.

These penalties were assigned by considering the allowed periods for each regime and year. The periods allowed for morning sessions- are periods 0, 1, 2, 3, and 4 (which correspond to the time slot from 8 AM to 1 PM). The periods allowed for afternoon sessions are periods 5, 6, 7, 8, and 9 (which correspond to the time slot from 1 PM to 7 PM), and the periods allowed for evening sessions are periods 10, 11, 12, 13, 14, and 15 (which correspond to the time slot from 7 PM to midnight).

In the provided table, an excerpt is shown to illustrate how these penalties are assigned. The Table shows that the penalty values increase gradually as the periods progress throughout the day, indicating a preference for earlier class slots, in each regime.

Table 6 - Penalty Values Assigned to Different Class Types Across Time Periods

Course	Type	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
ALGAN	T	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5
ALGAN	TP	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5
ALGAN	PL	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5
APROG	T	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5
APROG	TP	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5
APROG	PL	0	1	2	3	4	0	1	2	3	4	0	1	2	3	4	5

- Assignment of values to a_i coefficients according to requests from the professors, students or department in general for specific days of the week *i*.

The a_i coefficients are designed to influence the scheduling of classes based on preferred days of the week, incorporating requests from professors, students, or the department. These coefficients allow the model to prioritize certain days over others, ensuring that the schedule aligns with overall preferences.

The preference for earlier days in the week is reflected in the incremental assignment of penalty values. The table below illustrates how penalties are calculated for each day:

Table 7 - Penalty values assigned to each day of the week based on scheduling preferences.

Day	Penalty for each day
0	0
1	2
2	4
3	6
4	8

This system of increasing penalties effectively steers the scheduling of classes towards earlier in the week, aligning with the common preference for front-loading the academic schedule. This not only balances the weekly workload but also accommodates the tendency for both students and faculty to favor earlier days for intensive academic activities, leaving later days for lighter schedules or other commitments.

– Assignment of values to $b_{i,j,l}$ coefficients according to professor *l*'s preferences for teaching during period *j* on day *i*.

The values assigned to the $b_{i,j,l}$ coefficients are based on the preferences of professors for teaching during specific periods on specific days. These coefficients are crucial because they reflect the individual preferences of professors, which are essential for creating a timetable that aligns with both personal and institutional needs. The higher a professor's preference for a particular time slot, the lower the penalty value assigned.

– Assignment of values to d_l coefficients to minimize the number of days each professor *l* teaches.

The $z_{i,l}$ variable is designed to manage and penalize the total number of days that a professor *l* is required to teach. This constraint is important for balancing the teaching load across the week, ensuring that professors are not overly burdened with teaching every single day. The aim is to minimize the number of days a professor is scheduled to teach, which can help create a more concentrated schedule with fewer, but potentially longer, teaching days.

In the objective function, each $z_{i,l}$ variable represents whether professor *l* teaches on day *i*. If professor *l* has classes scheduled on a particular day *i*, then $z_{i,l}$ is set to 1; otherwise, it remains 0. The penalty associated with each day a professor teaches is controlled by a constant d_l. This constant multiplies the total number of days a professor is scheduled to teach, contributing to the overall penalty in the objective function.

For instance, if a professor *l* is scheduled to teach on Monday, Wednesday, and Friday, the $z_{i,l}$ variables for those days would each be set to 1. Consequently, the objective function would accumulate a penalty of 3. d_l for this professor, which the model seeks to minimize. By minimizing this penalty, the model favors schedules that require professors to teach on fewer days, aligning with the preference for concentrated teaching schedules.

3.2.4. Normalization

To ensure consistency with the previously described information, the normalization of the objective function coefficients in the Mixed Integer Programming (MIP) model was essential in adjusting the different components of the function to a common scale. This approach prevents preferences with larger scales from dominating the optimization process.

In the presented model, the objective function minimizes four main components: the cost of assigning a class to a specific time slot, the distribution of classes throughout the week, the preferences of professors for specific times and days, and the minimization of the number of days each professor is scheduled. With the coefficients associated with these components defined empirically based on departmental and faculty preferences, the application of normalization techniques ensured that these preferences are comparable.

A suitable technique for this scenario is Min-Max normalization, which adjusts the values of each component to the [0, 1] range. This normalization is particularly useful when components have different magnitudes, as seen in the model, where penalties vary among coefficient (Grodzevich & Romanko, 2006.). The formula for Min-Max normalization is:

$$f_i' = \frac{f_i - min(f_i)}{max(f_i) - min(f_i)} \tag{22}$$

To apply this technique, the first step was to identify the range of values for each component of the objective function, denoted as f_i. This was done by calculating the $\min(f_i)$ and $\max(f_i)$ values for each objective. The minimum for each component was determined by solving the relaxation of the problem, minimizing the respective objective function, meaning that only the specific objective was considered without accounting for the others. On the other hand, the maximum corresponds to the value of the feasible solution, obtained by solving the MIP problem, where again, each objective was optimized individually, without considering the remaining objectives. This approximation to the calculation of the $\min(f_i)$ and $\max(f_i)$ values for each objective is justified by the high computational times required to solve to optimality the single objective MIP problems.

Once these values were obtained, the integer programming problem was solved to compute the final value of f_i. Afterward, the Min-Max normalization formula was applied, scaling all the components to a common range. This allowed us to compare different aspects of the scheduling problem - such as professor preferences, distribution of classes, and minimizing teaching days - on the same scale, ensuring that no single component would dominate the optimization process.

The implementation of this normalization enabled a direct comparison between all components of the objective function. For instance, the penalties associated with scheduling preferences were adjusted to ensure that the cost of assigning a class to a less preferred time slot did not dominate other considerations. Similarly, preferences for days of the week were normalized, ensuring that the increasing penalties associated with later days did not skew the overall optimization.

Normalization also ensured that individual preferences of professors were treated fairly, allowing the model to balance personal constraints without compromising overall optimization. The term related to minimizing the number of teaching days for professors was adjusted to ensure that concentrating each professor's teaching on fewer days was weighted appropriately in relation to other components.

Normalization must be recalculated if the underlying data changes significantly, but this process is straightforward and essential to maintaining the integrity of the model in different instances. By repeating the normalization process whenever necessary, the model ensures that solutions continued to be fair and balanced, regardless of the specific constraints or preferences in a given iteration of the problem.

3.3. Data used on the computational tests

To implement and validate the adapted model, real data provided by the Mechanical Engineering Department was used for testing. The data was combined to align with the specific characteristics of the case study.

The provided data is stored in an Excel file (Turmas_22-23.xls) containing detailed information on courses, the duration and type of each class, instructors, and the student groups to which each class is assigned. Table 8 illustrates the organization of this data.

Table 8 – Organizational structure of the course data provided by the mechanical engineering department.

N.º Students	Classsroom		1NA	1NB
69	35	FSIAP 1h T 2h TP	T 1 Docente: MPA	
			TP 1 Docente: MPA	TP 2 Docente:MPA
41	21	APROG 2h T 2hPL	T 1 Docente: JSM	
			PL 1 Docente: DPP	PL 2 Docente: DPP
47	24	ALGAN 2h T 2h TP	T 1 Docente: MGM	
			TP 1 Docente: MGM	TP 2 Docente: GCV
30	15	DESET 2h TP 2h PL	TP 1 ALS	
			PL 1 Docente: ALS	PL 2 Docente: ALS
44	22	CMATE 2h T 2h PL	T 1 Docente: RBC	
			PL 1 Docente: TSP	PL 2 Docente: TSP
21	21	IENG1 1h T 2h PL	T 1 Docente: LMD	
			PL 1 Docente: AVP	

To make the data usable as input, it was necessary to reorganize the way the information was structured in the Excel file. Starting from the initially provided tables, we developed new tables for each academic year and program format. These tables include the following details:

- The degree.
- The semester.

- The course.
- The year (1st, 2nd, 3rd).
- The program format (Daytime or Evening).
- The language of instruction.
- The type of each class.
- The duration, in hours, of each class.
- The instructor.
- The student groups.

The value "1" is used to indicate the association of a specific class type, taught by a particular professor, with a given student group. The Table 9 is structured to organize data related to course scheduling and teaching assignments across different parameters. Each row in the table represents a unique combination of degree, semester, course, academic year, program, language, class type, and professor, with columns A and B (in this example) representing different student groups or classes.

For instance, when a professor teaches a class of a particular type (such as Theory or Practical) for a specific course in a given semester and year, and this class is assigned to a student group (A or B), the value "1" is placed in the corresponding cell under that student group. This indicates that the class taught by the professor is associated with that student group.

This structured approach allows for a clear understanding of which classes each professor is teaching and which student groups are involved. It also helps in identifying commonalities and differences between student groups regarding class assignments.

Table 9 - Class assignments by professor and student group.

Degree	Semester	Course	Year	Program	Language	Type	Duration	Professor	A	B
LEM	1	ALGAN	1	Noturno	PT	T	2h	MGM	1	1
LEM	1	ALGAN	1	Noturno	PT	TP	2h	MGM	1	
LEM	1	ALGAN	1	Noturno	PT	TP	2h	GCV		1
LEM	1	APROG	1	Noturno	PT	T	2h	JSM	1	1
LEM	1	APROG	1	Noturno	PT	PL	2h	DPP	1	
LEM	1	APROG	1	Noturno	PT	PL	2h	DPP		1

3.3.1. CPLEX integration and IP gap configuration

To solve the optimization problems, the model was integrated with CPLEX, a solver known for its efficiency and robustness in handling large-scale problems. The interface between Python and CPLEX was set up to ensure smooth transmission of the data structured in lists and tuples, ensuring that the data was properly formatted for processing by CPLEX.

In the optimization process, the CPLEX solver was configured to efficiently balance solution quality and computational time through the adjustment of the Mixed Integer Programming (IP) gap. The IP gap parameter, defined in the solver as gap, was set to 0.05, which corresponds to a 5% tolerance level.

The IP gap is a critical parameter that controls the trade-off between solution optimality and the time required to reach it. By setting the gap to 0.05, the solver was instructed to stop the optimization process once it found a solution that is within 5% of the best possible solution, or the optimal solution.

This approach is particularly useful when dealing with large or complex optimization problems where finding the absolute optimal solution may require a significant amount of time and computational resources. Allowing a small gap ensures that a near-optimal solution is obtained within a reasonable timeframe, which is often more practical in real-world applications.

The 5% gap strikes a balance by ensuring that the solution is sufficiently close to optimal while also preventing the solver from spending excessive time on marginal improvements. This configuration is crucial in scenarios where timely decision-making is essential, and a perfect solution is less critical than a good solution delivered quickly.

4. RESULTS AND DISCUSSION

This chapter provides an overview of the scheduling optimization results. It begins with the presentation of the data from two scenarios: one with a single course (LEM) and another with two courses (LEM and LEMA). The results are shown in detailed schedules for students, professors, and rooms, highlighting how the model manages class times, avoids conflicts, and allocates resources.

Following the presentation, the discussion section evaluates the effectiveness of the scheduling model in both scenarios. It addresses the model's success in meeting scheduling needs, handling multiple courses, and identifying any limitations. This chapter aims to offer insights into the performance of the scheduling algorithm and its impact on academic scheduling.

4.1. Presentation of the results

To provide clarity in interpreting the scheduling results, a Python script was created to export the data into Excel spreadsheets. This process ensures the systematic organization and visualization of schedules for student groups, professors, and rooms in an accessible format.

The scheduling data was exported considering two scenarios:

1) The first scenario considered only one course, LEM.
2) The second scenario considered two courses, LEM and LEMA.

These two scenarios were designed to evaluate whether the algorithm can adapt not only based on student program and academic year but also according to the specific course. By including multiple courses in the second scenario, it was possible to assess the algorithm's flexibility in managing more complex scheduling demands.

In both cases, the data was exported to Excel files in a similar format, enabling efficient analysis and verification.

This way, to provide a clearer interpretation of the results for each group of students, the data for all classes were initially exported together In Table 10 it is possible to see a portion of the results obtained for the student groups 1NA and 1NB of the first year in the evening regime for the LEM degree. This method of exporting allowed for the verification of several important aspects: ensuring that no class or professor had overlapping sessions, checking that common classes between different groups were properly allocated, and confirming that the schedules for each class were appropriately compacted. The complete results are provided in Appendix A.

Table 10 - Extract of consolidated results for all group of students considering one course.

LEM-N1	*1NA*	*1NB*
	Seg	
18h-19h	75,DESET, ALS, PL, F214	73,CMATE-M, TSP, PL, F221
19h-20h	75,DESET, ALS, PL, F214	73,CMATE-M, TSP, PL, F221
20h-21h	72,CMATE-M, TSP, PL, F218	70,APROG, DPP, PL, F216
21h-22h	72,CMATE-M, TSP, PL, F218	70,APROG, DPP, PL, F216
22h-23h	69,APROG, DPP, PL, F216	79,FSIAP, MPA, TP, F317
23h-24h	69,APROG, DPP, PL, F216	79,FSIAP, MPA, TP, F317
	Ter	
18h-19h	78,FSIAP, MPA, TP, F209	67,ALGAN, GCV, TP, F204
19h-20h	78,FSIAP, MPA, TP, F209	67,ALGAN, GCV, TP, F204
20h-21h	66,ALGAN, MGM, TP, F317	76,DESET, ALS, PL, F322
21h-22h	66,ALGAN, MGM, TP, F317	76,DESET, ALS, PL, F322
22h-23h	74,DESET, ALS, TP, F208	74,DESET, ALS, TP, F208
23h-24h	74,DESET, ALS, TP, F208	74,DESET, ALS, TP, F208

This approach made it easier to cross-check critical scheduling elements. By consolidating the data, it was possible to quickly identify any potential conflicts, such as overlapping classes, and ensure that shared classes across different groups were aligned correctly. Additionally, the compactness of the class schedules could be evaluated, ensuring efficient time distribution and minimal gaps between sessions. The attached document contains the full details of this analysis.

The scheduling data for student groups was also exported in a format that allows for the analysis of each group's timetable. This includes distinctions based on academic year, specific courses, and the type of class (such as theoretical or practical sessions). The schedule for each group contains the following detailed information:

- Class Number
- Subject
- Professor
- Type of Class
- Assigned Room

This structured approach enables users to view the timetable for each group in detail, making it easier to manage and understand the schedule on a per-class basis. For demonstration, Table 11 shows a portion of a timetable, organized by course name, academic year, regime, and class. This detailed layout ensures that all the necessary scheduling information is readily available and well-organized for efficient use.

Table 11 – Extract of the schedule for a specific group of students considering one course.

1DA	Seg	Ter	Qua	Qui	Sex
8h-9h	IENG1, SCF, PL, F224	DESET, AGS, TP, F317	FSIAP, JNP, TP, F204	APROG, JSM, PL, F225	ALGAN, MGM, T, I301
9h-10h	IENG1, SCF, PL, F224	DESET, AGS, TP, F317	FSIAP, JNP, TP, F204	APROG, JSM, PL, F225	ALGAN, MGM, T, I301
10h-11h	IENG1, LMD, T, F341	DESET, AGS, PL, F216	ALGAN, MGM, TP, F208	APROG, JSM, T, F341	CMATE-M, RBC, T, I301
11h-12h	CMATE-M, FAF, PL, F216	DESET, AGS, PL, F216	ALGAN, MGM, TP, F208	APROG, JSM, T, F341	CMATE-M, RBC, T, I301
12h-13h	CMATE-M, FAF, PL, F216	FSIAP, MPA, T, I301			

The schedule for each professor is organized in a detailed, individualized format, similar to the first method of data export used for student groups. Each professor's schedule contains the following key elements:

- Class Number
- Subject
- Assigned Room
- Group of students

This structure helps in providing a clear overview of the teaching assignments for each educator, showing which classes they are teaching, at what time, and to which group of students. This format ensures transparency and ease of access, allowing professors and administrators to efficiently manage their time and responsibilities.

Table 12 provides an example of a professor's schedule, illustrating how the timetable is structured across the week.

Table 12 - Extract of the schedule for a specific professor considering one course.

LAM	Seg	Ter	Qua	Qui	Sex
8h-9h					
9h-10h					
10h-11h					
11h-12h					
12h-13h					
13h-14h	108, MECA2, TP, F208, 2DA	109, MECA2, TP, F204, 2DB			
14h-15h	108, MECA2, TP, F208, 2DA	109, MECA2, TP, F204, 2DB			
15h-16h	110, MECA2, TP, F204, 2DC				
16h-17h	110, MECA2, TP, F204, 2DC				
17h-18h					
18h-19h		205, ORMAQ, TP, F207, 3NC			
19h-20h		205, ORMAQ, TP, F207, 3NC			
20h-21h	204, ORMAQ, TP, F319, 3NB				
21h-22h	204, ORMAQ, TP, F319, 3NB				
22h-23h	203, ORMAQ, TP, F207, 3NA				
23h-24h	203, ORMAQ, TP, F207, 3NA				

The room scheduling data was handled differently from the schedules for students and professors. The main goal was to provide a comprehensive view of room occupancy across all days and time slots. This approach is crucial for understanding the utilization and availability of classrooms throughout the week.

The results were consolidated into a single Excel sheet, providing a full overview of how each room is used during different times and on different days. The key information included in the room schedules consists of:

- Class Number
- Subject
- Professor
- Type of class:
- Group of students

below shows an extract of room occupancy data, illustrating how different rooms are used throughout the week. For a full overview of room schedules, including detailed information about room utilization and availability, please refer to Appendix B.

Table 13 below shows an extract of room occupancy data, illustrating how different rooms are used throughout the week. For a full overview of room schedules, including detailed information about room utilization and availability, please refer to Appendix B.

Table 13 - Extract of the schedules for all the classrooms considering one course.

	F202	*F203*	*F204*	*F207*
	Seg			
8h-9h	175,ORMAQ, ELZ, TP,F202, 3DH	50,FSIAP, MPA, TP,F203, 1DE	195,TRFCA-M, CMI, TP,F204, 3DF	53,FSIAP, APA, TP,F207, 1DI
9h-10h	175,ORMAQ, ELZ, TP,F202, 3DH	50,FSIAP, MPA, TP,F203, 1DE	195,TRFCA-M, CMI, TP,F204, 3DF	53,FSIAP, APA, TP,F207, 1DI
10h-11h	193,TRFCA-M, LOC, TP,F202, 3DC	178,PFAB2, RPM, TP,F203, 3DA		
11h-12h	193,TRFCA-M, LOC, TP,F202, 3DC	178,PFAB2, RPM, TP,F203, 3DA		174,ORMAQ, DPG, TP,F207, 3DG
12h-13h				174,ORMAQ, DPG, TP,F207, 3DG
13h-14h	129,TERMO, ARJ, TP,F202, 2DC	121,MTNMT, JFS, TP,F203, 2DD		
14h-15h	129,TERMO, ARJ, TP,F202, 2DC	121,MTNMT, JFS, TP,F203, 2DD		
15h-16h	122,MTNMT, AGM, TP,F202, 2DE		110,MECA2, LAM, TP,F204, 2DC	
16h-17h	122,MTNMT, AGM, TP,F202, 2DE	128,TERMO, RFR, TP,F203, 2DB	110,MECA2, LAM, TP,F204, 2DC	105,MATE2, DC1, TP,F207, 2DG
17h-18h		128,TERMO, RFR, TP,F203, 2DB		105,MATE2, DC1, TP,F207, 2DG
18h-19h				213,TRFCA-M, CDA, TP,F207, 3NC
19h-20h				213,TRFCA-M, CDA, TP,F207, 3NC
20h-21h	208,PFAB2, AVP, TP,F202, 3NC		211,TRFCA-M, CDA, TP,F204, 3NA	145,MECA2, HDA, TP,F207, 2NC
21h-22h	208,PFAB2, AVP, TP,F202, 3NC		211,TRFCA-M, CDA, TP,F204, 3NA	145,MECA2, HDA, TP,F207, 2NC
22h-23h	143,MECA2, HDA, TP,F202, 2NA	150,TERMO, ARJ, TP,F203, 2NB		203,ORMAQ, LAM, TP,F207, 3NA
23h-24h	143,MECA2, HDA, TP,F202, 2NA	150,TERMO, ARJ, TP,F203, 2NB		203,ORMAQ, LAM, TP,F207, 3NA

4.2. Discussion of the results

The results discussed below correspond to the first scenario, where only one course (LEM) was considered. In this scenario, the focus was on evaluating the effectiveness of the scheduling optimization model in terms of managing class durations, avoiding conflicts, and ensuring appropriate room allocation. Following this, the second scenario, which considers two courses (LEM and LEMA), will be discussed, highlighting the differences and challenges faced in that context.

The results of the scheduling optimization model for the first scenario demonstrate significant achievements in managing class durations, avoiding conflicts, and ensuring appropriate room allocation.

As seen through the schedule analysis provided in Appendix A, the results obtained from the model for the first scenario are as follows:

- The schedule meets the required duration for each class, ensuring that all sessions are neither too long nor too short. This consistency is crucial for maintaining educational standards across the curriculum.
- The scheduling system effectively avoids conflicts, with no double-booked rooms or professors assigned to multiple classes at the same time. This results in a conflict-free timetable that optimizes the use of available resources.
- Classes are distributed evenly throughout the week, with a noticeable emphasis on earlier time slots. This aligns with the objective function's design, which penalizes later periods more heavily. The result is a timetable that efficiently uses academic time and resources.
- For multi-period classes, the model ensures consecutive scheduling to avoid interruptions and provide a continuous learning experience.
- Each class is assigned to an appropriate room, whether it be a laboratory for practical sessions or a lecture hall for theoretical ones. This careful allocation supports the effective delivery of classes.
- The scheduling model fully covers the curriculum, ensuring that all subjects and academic years are included, leaving no gaps.

In addition to meeting the technical requirements, the timetable incorporates professor and student preferences:

- **Professor Preferences**: Professors' classes are compacted into fewer days per week (usually two or three), minimizing their presence on campus. The model also avoids scheduling classes on days less preferred by individual professors, leading to a balanced and satisfying work schedule.
- **Student Preferences**: The scheduling prioritizes early class times, reducing gaps between sessions and organizing classes into consecutive blocks. This allows students to complete their academic obligations earlier in the day, providing flexibility for other activities or study.

In the second scenario, where both LEM and LEMA courses were considered, the results varied. The primary objective was to determine whether the algorithm could adapt to scheduling multiple courses simultaneously, rather than achieving the optimal solution. A time limit of 2 hours was set, and the results obtained reflect a 50% optimality gap.

In this scenario, as observed from the results provided in Appendix B and comparing with the results related to the first scenario:

- The constraints were respected, ensuring no overlaps in class times or room assignments.
- However, the classes were not compacted as tightly as desired due to the 50% gap. This gap resulted from technical limitations with the computer's performance during the optimization process.

Despite not achieving the optimal solution, the results demonstrate that the algorithm can handle a scenario with multiple courses. While not the best possible outcome, the solution is still relevant and provides valuable insight into the problem-solving capabilities of the algorithm.

Additionally, it was found that the number of available rooms for the Department of Mechanical Engineering was insufficient to accommodate all the necessary classes. As a result, fictitious rooms were introduced into the model to allow for a feasible solution. In a real-world scenario, this would require further evaluation to address the shortage of physical rooms.

The tests were conducted on an Asus Vivobook computer equipped with an Intel(R) Core(TM) i7-8565U CPU @ 1.80GHz, with a maximum frequency of 1.99 GHz. This processor belongs to the 8th generation of Intel Core processors.

5. CONCLUSION

This chapter provides an overview of the work completed throughout the dissertation project, detailing how the main objectives were achieved and highlighting the challenges encountered during the process. It begins by summarizing the key tasks and milestones accomplished, then moves on to discuss the specific limitations faced during the research. Finally, the chapter concludes with a brief exploration of potential areas for future research, suggesting directions that could build on the findings and address any gaps or issues identified during the project.

5.1. Final Conclusions

The primary objective of this project was to develop a DSS capable of automating the timetable creation process at ISEP, a task traditionally performed manually. Manual timetable creation is often time-consuming and complex, typically starting from previous years' schedules. This approach is inefficient and prone to errors, especially when handling multiple constraints such as classroom availability, professor preferences, student requirements, and the academic curriculum. To address these challenges, a comprehensive review of the existing literature on university timetable construction was conducted. This review helped identify the most critical issues and constraints, providing a foundation for developing a more sophisticated, algorithm-based solution.

Two scenarios were considered to evaluate the adaptability of the DSS: the first involving a single course (LEM) and the second involving two courses (LEM and LEMA). In both cases, the algorithm was able to generate timetables that respected the constraints and requirements of the system. In the first scenario, the results were highly efficient, with schedules that met all constraints, including class distribution, room allocation, and the integration of both professor and student preferences. This demonstrated the algorithm's ability to automate the timetable process successfully, eliminating overlaps and ensuring optimal use of resources.

In the second scenario, which included two courses, the focus was on testing whether the algorithm could adapt to more complex scheduling needs across multiple programs. Due to technical constraints, a time limit was introduced, and the results were obtained with a 50% optimality gap within a two-hour timeframe. Although the solution was not fully compact, as some classes were spread out more than desired, the algorithm still managed to respect all critical constraints. This showed that the algorithm could indeed handle multiple courses. Additionally, the lack of available rooms required the introduction of fictitious rooms to allocate all classes, highlighting a real-world issue that would need to be addressed for full implementation.

The project's outcomes indicate significant advancements in automating the timetable creation process, demonstrating the algorithm's ability to handle different scenarios while meeting essential requirements. However, there are areas for improvement, including the issue of insufficient classroom availability. This issue is evident from the results obtained in Scenario 1, where only one course (LEM) was considered. In this case, 37% of the available time slots for regular classrooms were filled, 39% of the available time slots for laboratory rooms were occupied, and 30% of the periods for amphitheaters were used. Considering these results are based on just one course, and there are still two additional bachelor's and five master's degrees to schedule, it becomes clear that there is a significant problem with the availability of enough rooms to adequately allocate all classes. Additionally, the weighting of various factors in the algorithm needs further consideration.

The current weights were based on empirical values, and their optimization will be crucial for achieving more precise and effective scheduling solutions in future implementations.

Overall, the results provide a strong foundation for future development and implementation of the algorithm across the entire department at DEM-ISEP.

5.2. Limitations and future research

Addressing the University Course Timetabling Problem (UCTP) presents considerable challenges, largely due to the complex nature of the constraints involved. This study focused primarily on developing a robust data structure for the algorithm implemented in Python, with the aim of managing the complexities inherent in timetable scheduling. Despite these efforts, several limitations emerged, highlighting the difficulties of solving such a multifaceted problem.

As the scope of the problem expands to include more constraints, courses, instructors, and rooms, the complexity increases significantly. This underscores the need for more sophisticated algorithms capable of managing these complexities effectively. The addition of new constraints often exacerbates these challenges, revealing the necessity for ongoing advancements in algorithmic efficiency.

The complexity of timetabling models becomes more pronounced with the introduction of additional constraints. Although the algorithm developed in this study made significant strides in addressing many scheduling challenges, it struggled with certain constraints as the problem's scale grew. Future research should focus on enhancing the algorithm's capability to integrate a broader range of constraints while maintaining efficiency. This involves developing strategies to manage the growing intricacies associated with larger and more complex scheduling environments.

Future research should also address specific scenarios not fully covered by the current model. For instance, incorporating constraints related to students participating in internships during the academic year would enhance the realism and practicality of the timetables. In some programs, students complete curricular internships for two days per week, which necessitates scheduling their classes over the remaining three days. Similarly, future models should accommodate courses taught in English to meet diverse language requirements.

Another crucial aspect for future work is minimizing room changes between classes. Reducing the number of times professors and students need to switch rooms and shortening the distance between rooms when changes are necessary is a key concern for many users. Addressing this issue would significantly enhance the overall user experience, making transitions during the day more efficient and less disruptive.

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APPENDIX A – SCHEDULS FOR ALL GROUPS OF STUDENTS CONSIDERING ONE COURSE

LEM-D1	2DA	2DB	2DC	2DD	2DE	2DF	2DG	2DH	2DI	2DJ
	Seg									
8h-9h	56,IENG1, SCF, PL, F224	37,DESET, RDM, PL, F226	23,CMATE-M, FAF, PL, F214	59,IENG1, ICT, PL, F221	50,FSIAP, MPA, TP, F203	51,FSIAP, JNP, TP, F317	15,APROG, NVM, PL, F225	16,APROG, AFO, PL, F218	53,FSIAP, APA, TP, F207	53,FSIAP, APA, TP, F207
9h-10h	56,IENG1, SCF, PL, F224	37,DESET, RDM, PL, F226	23,CMATE-M, FAF, PL, F214	59,IENG1, ICT, PL, F221	50,FSIAP, MPA, TP, F203	51,FSIAP, JNP, TP, F317	15,APROG, NVM, PL, F225	16,APROG, AFO, PL, F218	53,FSIAP, APA, TP, F207	53,FSIAP, APA, TP, F207
10h-11h	54,IENG1, LMD, T, F341	54,IENG1, LMD, T, F341	54,IENG1, LMD, T, F341	54,IENG1, LMD, T, F341	54,IENG1, LMD, T, F341	47,FSIAP, MPA, T, I201	47,FSIAP, MPA, T, I201	47,FSIAP, MPA, T, I201	47,FSIAP, MPA, T, I201	47,FSIAP, MPA, T, I201
11h-12h	21,CMATE-M, FAF, PL, F216	31,DESET, RDM, TP, F208	32,DESET, SCF, TP, F319	32,DESET, SCF, TP, F319	25,CMATE-M, RBC, PL, F218	61,IENG1, IAA, PL, F224	42,DESET, EFM, PL, F226	63,IENG1, ICT, PL, F322	35,DESET, CPC, TP, F209	35,DESET, CPC, TP, F209
12h-13h	21,CMATE-M, FAF, PL, F216	31,DESET, RDM, TP, F208	32,DESET, SCF, TP, F319	32,DESET, SCF, TP, F319	25,CMATE-M, RBC, PL, F218	61,IENG1, IAA, PL, F224	42,DESET, EFM, PL, F226	63,IENG1, ICT, PL, F322	35,DESET, CPC, TP, F209	35,DESET, CPC, TP, F209
	Ter									
8h-9h	30,DESET, AGS, TP, F317	57,IENG1, SCF, PL, F216	11,APROG, JSM, PL, F322	12,APROG, RAL, PL, F224	33,DESET, OCF, TP, F203	33,DESET, OCF, TP, F203	34,DESET, EFM, TP, F208	34,DESET, EFM, TP, F208	44,DESET, CPC, PL, F221	18,APROG, AFO, PL, F226
9h-10h	30,DESET, AGS, TP, F317	57,IENG1, SCF, PL, F216	11,APROG, JSM, PL, F322	12,APROG, RAL, PL, F224	33,DESET, OCF, TP, F203	33,DESET, OCF, TP, F203	34,DESET, EFM, TP, F208	34,DESET, EFM, TP, F208	44,DESET, CPC, PL, F221	18,APROG, AFO, PL, F226
10h-11h	36,DESET, AGS, PL, F216	22,CMATE-M, FAF, PL, F214	3,ALGAN, MGM, TP, F208	3,ALGAN, MGM, TP, F208	60,IENG1, IAA, PL, F224	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301
11h-12h	36,DESET, AGS, PL, F216	22,CMATE-M, FAF, PL, F214	3,ALGAN, MGM, TP, F208	3,ALGAN, MGM, TP, F208	60,IENG1, IAA, PL, F224	14,APROG, AFO, PL, F221	62,IENG1, SCF, PL, F218	43,DESET, EFM, PL, F322	6,ALGAN, GCV, TP, F207	6,ALGAN, GCV, TP, F207
12h-13h	46,FSIAP, MPA, T, I301	46,FSIAP, MPA, T, I301	46,FSIAP, MPA, T, I301	46,FSIAP, MPA, T, I301	46,FSIAP, MPA, T, I301	14,APROG, AFO, PL, F221	62,IENG1, SCF, PL, F218	43,DESET, EFM, PL, F322	6,ALGAN, GCV, TP, F207	6,ALGAN, GCV, TP, F207
	Qua									
8h-9h	48,FSIAP, JNP, TP, F204	48,FSIAP, JNP, TP, F204	58,IENG1, ICT, PL, F216	39,DESET, SCF, PL, F224	13,APROG, EVF, PL, F225	41,DESET, OCF, PL, F322	1,ALGAN, MGM, T, I201	1,ALGAN, MGM, T, I201	1,ALGAN, MGM, T, I201	1,ALGAN, MGM, T, I201
9h-10h	48,FSIAP, JNP, TP, F204	48,FSIAP, JNP, TP, F204	58,IENG1, ICT, PL, F216	39,DESET, SCF, PL, F224	13,APROG, EVF, PL, F225	41,DESET, OCF, PL, F322	1,ALGAN, MGM, T, I201	1,ALGAN, MGM, T, I201	1,ALGAN, MGM, T, I201	1,ALGAN, MGM, T, I201
10h-11h	2,ALGAN, MGM, TP, F208	2,ALGAN, MGM, TP, F208	38,DESET, SCF, PL, F218	24,CMATE-M, FAF, PL, F224	40,DESET, OCF, PL, F221	26,CMATE-M, SMS, PL, F226	5,ALGAN, GCV, TP, F319	5,ALGAN, GCV, TP, F319	17,APROG, EVF, PL, F216	45,DESET, CPC, PL, F214
11h-12h	2,ALGAN, MGM, TP, F208	2,ALGAN, MGM, TP, F208	38,DESET, SCF, PL, F218	24,CMATE-M, FAF, PL, F224	40,DESET, OCF, PL, F221	26,CMATE-M, SMS, PL, F226	5,ALGAN, GCV, TP, F319	5,ALGAN, GCV, TP, F319	17,APROG, EVF, PL, F216	45,DESET, CPC, PL, F214
12h-13h										
	Qui									
8h-9h	9,APROG, JSM, PL, F225	10,APROG, RAL, PL, F224	49,FSIAP, MPA, TP, F204	49,FSIAP, MPA, TP, F204	4,ALGAN, MGM, TP, F202	4,ALGAN, MGM, TP, F202	27,CMATE-M, PPS, PL, F322	28,CMATE-M, SMS, PL, F216	64,IENG1, ICT, PL, F214	64,IENG1, ICT, PL, F214
9h-10h	9,APROG, JSM, PL, F225	10,APROG, RAL, PL, F224	49,FSIAP, MPA, TP, F204	49,FSIAP, MPA, TP, F204	4,ALGAN, MGM, TP, F202	4,ALGAN, MGM, TP, F202	27,CMATE-M, PPS, PL, F322	28,CMATE-M, SMS, PL, F216	64,IENG1, ICT, PL, F214	64,IENG1, ICT, PL, F214
10h-11h	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342
11h-12h	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	7,APROG, JSM, T, F341	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342
12h-13h										
	Sex									
8h-9h	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	52,FSIAP, APA, TP, F319	52,FSIAP, APA, TP, F319	29,CMATE-M, SMS, PL, F214	29,CMATE-M, SMS, PL, F214
9h-10h	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	0,ALGAN, MGM, T, I301	52,FSIAP, APA, TP, F319	52,FSIAP, APA, TP, F319	29,CMATE-M, SMS, PL, F214	29,CMATE-M, SMS, PL, F214
10h-11h	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341
11h-12h	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	19,CMATE-M, RBC, T, I301	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341
12h-13h										

LEM-D2	2DA	2DB	2DC	2DD	2DE	2DF	2DG	2DH
				Seg				
13h-14h	108,MECA2, LAM, TP, F208	83,CEFAC, MON, PL, F225	129,TERMO, ARJ, TP, F202	121,MTNMT, JFS, TP, F203	96,EMELE, ATA, PL, F214	87,CEFAC, DER, PL, F224	88,CEFAC, MMA, PL, F322	115,MECA2, REM, TP, F317
14h-15h	108,MECA2, LAM, TP, F208	83,CEFAC, MON, PL, F225	129,TERMO, ARJ, TP, F202	121,MTNMT, JFS, TP, F203	96,EMELE, ATA, PL, F214	87,CEFAC, DER, PL, F224	88,CEFAC, MMA, PL, F322	115,MECA2, REM, TP, F317
15h-16h	82,CEFAC, ADP, PL, F226	83,CEFAC, MON, PL, F225	110,MECA2, LAM, TP, F204	85,CEFAC, JPR, PL, F214	122,MTNMT, AGM, TP, F202	87,CEFAC, DER, PL, F224	88,CEFAC, MMA, PL, F322	
16h-17h	82,CEFAC, ADP, PL, F226	128,TERMO, RFR, TP, F203	110,MECA2, LAM, TP, F204	85,CEFAC, JPR, PL, F214	122,MTNMT, AGM, TP, F202	113,MECA2, JOB, TP, F317	105,MATE2, DC1, TP, F207	105,MATE2, DC1, TP, F207
17h-18h	82,CEFAC, ADP, PL, F226	128,TERMO, RFR, TP, F203		85,CEFAC, JPR, PL, F214		113,MECA2, JOB, TP, F317	105,MATE2, DC1, TP, F207	105,MATE2, DC1, TP, F207
				Ter				
13h-14h	92,EMELE, ATA, PL, F216	109,MECA2, LAM, TP, F204	120,MTNMT, PUR, TP, F203	95,EMELE, PMA, PL, F218	131,TERMO, RFR, TP, F202	132,TERMO, PAA, TP, F208	114,MECA2, JOB, TP, F209	89,CEFAC, MMA, PL, F224
14h-15h	92,EMELE, ATA, PL, F216	109,MECA2, LAM, TP, F204	120,MTNMT, PUR, TP, F203	95,EMELE, PMA, PL, F218	131,TERMO, RFR, TP, F202	132,TERMO, PAA, TP, F208	114,MECA2, JOB, TP, F209	89,CEFAC, MMA, PL, F224
15h-16h	127,TERMO, RFR, TP, F209	119,MTNMT, JFS, TP, F204	94,EMELE, ATA, PL, F221	111,MECA2, JOB, TP, F207	86,CEFAC, DER, PL, F216	123,MTNMT, AGM, TP, F203		89,CEFAC, MMA, PL, F224
16h-17h	127,TERMO, RFR, TP, F209	119,MTNMT, JFS, TP, F204	94,EMELE, ATA, PL, F221	111,MECA2, JOB, TP, F207	86,CEFAC, DER, PL, F216	123,MTNMT, AGM, TP, F203	133,TERMO, PAA, TP, F319	133,TERMO, PAA, TP, F319
17h-18h	90,EMELE, ATA, T, F342	90,EMELE, ATA, T, F342	90,EMELE, ATA, T, F342	90,EMELE, ATA, T, F342	86,CEFAC, DER, PL, F216		133,TERMO, PAA, TP, F319	133,TERMO, PAA, TP, F319
				Qua				
13h-14h	101,MATE2, ASB, TP, F202	102,MATE2, DC1, TP, F203	84,CEFAC, ADP, PL, F221	130,TERMO, RFR, TP, F208	112,MECA2, JOB, TP, F207	97,EMELE, PMA, PL, F224	124,MTNMT, PUR, TP, F317	124,MTNMT, PUR, TP, F317
14h-15h	101,MATE2, ASB, TP, F202	102,MATE2, DC1, TP, F203	84,CEFAC, ADP, PL, F221	130,TERMO, RFR, TP, F208	112,MECA2, JOB, TP, F207	97,EMELE, PMA, PL, F224	124,MTNMT, PUR, TP, F317	124,MTNMT, PUR, TP, F317
15h-16h	118,MTNMT, PUR, TP, F204	93,EMELE, PMA, PL, F322	84,CEFAC, ADP, PL, F221		104,MATE2, DC1, TP, F207	104,MATE2, DC1, TP, F207	98,EMELE, ATA, PL, F224	98,EMELE, ATA, PL, F224
16h-17h	118,MTNMT, PUR, TP, F204	93,EMELE, PMA, PL, F322	103,MATE2, ASB, TP, F319	103,MATE2, ASB, TP, F319	104,MATE2, DC1, TP, F207	104,MATE2, DC1, TP, F207	98,EMELE, ATA, PL, F224	98,EMELE, ATA, PL, F224
17h-18h			103,MATE2, ASB, TP, F319	103,MATE2, ASB, TP, F319	91,EMELE, ATA, T, I301	91,EMELE, ATA, T, I301	91,EMELE, ATA, T, I301	91,EMELE, ATA, T, I301
				Qui				
13h-14h	125,TERMO, PAA, T, F341	125,TERMO, PAA, T, F341	125,TERMO, PAA, T, F341	125,TERMO, PAA, T, F341	107,MECA2, JFJ, T, I301	107,MECA2, JFJ, T, I301	107,MECA2, JFJ, T, I301	107,MECA2, JFJ, T, I301
14h-15h	125,TERMO, PAA, T, F341	125,TERMO, PAA, T, F341	125,TERMO, PAA, T, F341	125,TERMO, PAA, T, F341	107,MECA2, JFJ, T, I301	107,MECA2, JFJ, T, I301	107,MECA2, JFJ, T, I301	107,MECA2, JFJ, T, I301
15h-16h	106,MECA2, JFJ, T, F341	106,MECA2, JFJ, T, F341	106,MECA2, JFJ, T, F341	106,MECA2, JFJ, T, F341	126,TERMO, PAA, T, F342	126,TERMO, PAA, T, F342	126,TERMO, PAA, T, F342	126,TERMO, PAA, T, F342
16h-17h	106,MECA2, JFJ, T, F341	106,MECA2, JFJ, T, F341	106,MECA2, JFJ, T, F341	106,MECA2, JFJ, T, F341	126,TERMO, PAA, T, F342	126,TERMO, PAA, T, F342	126,TERMO, PAA, T, F342	126,TERMO, PAA, T, F342
17h-18h								
				Sex				
13h-14h	116,MTNMT, MDC, T, F342	116,MTNMT, MDC, T, F342	116,MTNMT, MDC, T, F342	116,MTNMT, MDC, T, F342	100,MATE2, ASB, T, I301	100,MATE2, ASB, T, I301	100,MATE2, ASB, T, I301	100,MATE2, ASB, T, I301
14h-15h	116,MTNMT, MDC, T, F342	116,MTNMT, MDC, T, F342	116,MTNMT, MDC, T, F342	116,MTNMT, MDC, T, F342	100,MATE2, ASB, T, I301	100,MATE2, ASB, T, I301	100,MATE2, ASB, T, I301	100,MATE2, ASB, T, I301
15h-16h	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	117,MTNMT, AGM, T, F341	117,MTNMT, AGM, T, F341	117,MTNMT, AGM, T, F341	117,MTNMT, AGM, T, F341
16h-17h	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	117,MTNMT, AGM, T, F341	117,MTNMT, AGM, T, F341	117,MTNMT, AGM, T, F341	117,MTNMT, AGM, T, F341
17h-18h								

LEM-D3	2DA	2DB	2DC	2DD	2DE	2DF	2DG	2DH
				Seg				
8h-9h	163,ORGI1, ANT, TP, F208	164,ORGI1, JAQ, TP, F319	180,PFAB2, RPM, TP, F209	180,PFAB2, RPM, TP, F209	157,AUTO1, AFS, PL, F216	195,TRFCA-M, CMI, TP, F204	188,PROJ1, MOA, PL, F322	175,ORMAQ, ELZ, TP, F202
9h-10h	163,ORGI1, ANT, TP, F208	164,ORGI1, JAQ, TP, F319	180,PFAB2, RPM, TP, F209	180,PFAB2, RPM, TP, F209	157,AUTO1, AFS, PL, F216	195,TRFCA-M, CMI, TP, F204	188,PROJ1, MOA, PL, F322	175,ORMAQ, ELZ, TP, F202
10h-11h	178,PFAB2, RPM, TP, F203	184,PROJ1, ISP, PL, F214	193,TRFCA-M, LOC, TP, F202	193,TRFCA-M, LOC, TP, F202	186,PROJ1, CEC, PL, F225	187,PROJ1, RFS, PL, F221	188,PROJ1, MOA, PL, F322	197,TRFCA-M, CMI, TP, F317
11h-12h	178,PFAB2, RPM, TP, F203	184,PROJ1, ISP, PL, F214	193,TRFCA-M, LOC, TP, F202	193,TRFCA-M, LOC, TP, F202	186,PROJ1, CEC, PL, F225	187,PROJ1, RFS, PL, F221	174,ORMAQ, DPG, TP, F207	197,TRFCA-M, CMI, TP, F317
12h-13h		184,PROJ1, ISP, PL, F214			186,PROJ1, CEC, PL, F225	187,PROJ1, RFS, PL, F221	174,ORMAQ, DPG, TP, F207	
				Ter				
8h-9h	153,AUTO1, PJF, PL, F214	179,PFAB2, RPM, TP, F319	171,ORMAQ, DPG, TP, F204	171,ORMAQ, DPG, TP, F204	172,ORMAQ, AJC, TP, F209	158,AUTO1, FAL, PL, F225	196,TRFCA-M, LOC, TP, F202	189,PROJ1, MOA, PL, F218
9h-10h	153,AUTO1, PJF, PL, F214	179,PFAB2, RPM, TP, F319	171,ORMAQ, DPG, TP, F204	171,ORMAQ, DPG, TP, F204	172,ORMAQ, AJC, TP, F209	158,AUTO1, FAL, PL, F225	196,TRFCA-M, LOC, TP, F202	189,PROJ1, MOA, PL, F218
10h-11h	183,PROJ1, ISP, PL, F225	154,AUTO1, PJF, PL, F226	165,ORGI1, VEC, TP, F204	165,ORGI1, VEC, TP, F204	166,ORGI1, ANT, TP, F203	166,ORGI1, ANT, TP, F203		189,PROJ1, MOA, PL, F218
11h-12h	183,PROJ1, ISP, PL, F225	154,AUTO1, PJF, PL, F226	165,ORGI1, VEC, TP, F204	165,ORGI1, VEC, TP, F204	166,ORGI1, ANT, TP, F203	166,ORGI1, ANT, TP, F203	182,PFAB2, RPM, TP, F209	182,PFAB2, RPM, TP, F209
12h-13h	183,PROJ1, ISP, PL, F225						182,PFAB2, RPM, TP, F209	182,PFAB2, RPM, TP, F209
				Qua				
8h-9h	170,ORMAQ, RCM, TP, F208	170,ORMAQ, RCM, TP, F208	155,AUTO1, PJF, PL, F218	156,AUTO1, ADS, PL, F214	194,TRFCA-M, FAC, TP, F203	173,ORMAQ, DPG, TP, F202	159,AUTO1, FAL, PL, F221	160,AUTO1, AFS, PL, F226
9h-10h	170,ORMAQ, RCM, TP, F208	170,ORMAQ, RCM, TP, F208	155,AUTO1, PJF, PL, F218	156,AUTO1, ADS, PL, F214	194,TRFCA-M, FAC, TP, F203	173,ORMAQ, DPG, TP, F202	159,AUTO1, FAL, PL, F221	160,AUTO1, AFS, PL, F226
10h-11h	161,ORGI1, LMF, T, F342	161,ORGI1, LMF, T, F342	161,ORGI1, LMF, T, F342	161,ORGI1, LMF, T, F342	181,PFAB2, RPM, TP, F317	181,PFAB2, RPM, TP, F317	167,ORGI1, VEC, TP, F207	167,ORGI1, VEC, TP, F207
11h-12h	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	181,PFAB2, RPM, TP, F317	181,PFAB2, RPM, TP, F317	167,ORGI1, VEC, TP, F207	167,ORGI1, VEC, TP, F207
12h-13h	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	162,ORGI1, LMF, T, I201	162,ORGI1, LMF, T, I201	162,ORGI1, LMF, T, I201	162,ORGI1, LMF, T, I201
				Qui				
8h-9h	151,AUTO1, AFS, T, I301	151,AUTO1, AFS, T, I301	151,AUTO1, AFS, T, I301	151,AUTO1, AFS, T, I301	191,TRFCA-M, LOC, T, F341	191,TRFCA-M, LOC, T, F341	191,TRFCA-M, LOC, T, F341	191,TRFCA-M, LOC, T, F341
9h-10h	151,AUTO1, AFS, T, I301	151,AUTO1, AFS, T, I301	151,AUTO1, AFS, T, I301	151,AUTO1, AFS, T, I301	191,TRFCA-M, LOC, T, F341	191,TRFCA-M, LOC, T, F341	191,TRFCA-M, LOC, T, F341	191,TRFCA-M, LOC, T, F341
10h-11h	192,TRFCA-M, LOC, TP, F317	192,TRFCA-M, LOC, TP, F317	185,PROJ1, VHN, PL, F322	185,PROJ1, VHN, PL, F322	177,PFAB2, RPM, T, I201	177,PFAB2, RPM, T, I201	177,PFAB2, RPM, T, I201	177,PFAB2, RPM, T, I201
11h-12h	192,TRFCA-M, LOC, TP, F317	192,TRFCA-M, LOC, TP, F317	185,PROJ1, VHN, PL, F322	185,PROJ1, VHN, PL, F322	177,PFAB2, RPM, T, I201	177,PFAB2, RPM, T, I201	177,PFAB2, RPM, T, I201	177,PFAB2, RPM, T, I201
12h-13h			185,PROJ1, VHN, PL, F322	185,PROJ1, VHN, PL, F322				
				Sex				
8h-9h	168,ORMAQ, AJC, T, F341	168,ORMAQ, AJC, T, F341	168,ORMAQ, AJC, T, F341	168,ORMAQ, AJC, T, F341	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201
9h-10h	168,ORMAQ, AJC, T, F341	168,ORMAQ, AJC, T, F341	168,ORMAQ, AJC, T, F341	168,ORMAQ, AJC, T, F341	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201
10h-11h	176,PFAB2, LLM, T, F342	176,PFAB2, LLM, T, F342	176,PFAB2, LLM, T, F342	176,PFAB2, LLM, T, F342	152,AUTO1, ADS, T, I201	152,AUTO1, ADS, T, I201	152,AUTO1, ADS, T, I201	152,AUTO1, ADS, T, I201
11h-12h	176,PFAB2, LLM, T, F342	176,PFAB2, LLM, T, F342	176,PFAB2, LLM, T, F342	176,PFAB2, LLM, T, F342	152,AUTO1, ADS, T, I201	152,AUTO1, ADS, T, I201	152,AUTO1, ADS, T, I201	152,AUTO1, ADS, T, I201
12h-13h								

LEM-N1	1NA	1NB
	Seg	
18h-19h	75,DESET, ALS, PL, F214	73,CMATE-M, TSP, PL, F221
19h-20h	75,DESET, ALS, PL, F214	73,CMATE-M, TSP, PL, F221
20h-21h	72,CMATE-M, TSP, PL, F218	70,APROG, DPP, PL, F216
21h-22h	72,CMATE-M, TSP, PL, F218	70,APROG, DPP, PL, F216
22h-23h	69,APROG, DPP, PL, F216	79,FSIAP, MPA, TP, F317
23h-24h	69,APROG, DPP, PL, F216	79,FSIAP, MPA, TP, F317
	Ter	
18h-19h	78,FSIAP, MPA, TP, F209	67,ALGAN, GCV, TP, F204
19h-20h	78,FSIAP, MPA, TP, F209	67,ALGAN, GCV, TP, F204
20h-21h	66,ALGAN, MGM, TP, F317	76,DESET, ALS, PL, F322
21h-22h	66,ALGAN, MGM, TP, F317	76,DESET, ALS, PL, F322
22h-23h	74,DESET, ALS, TP, F208	74,DESET, ALS, TP, F208
23h-24h	74,DESET, ALS, TP, F208	74,DESET, ALS, TP, F208
	Qua	
18h-19h	81,IENG1, AVP, PL, F224	81,IENG1, AVP, PL, F224
19h-20h	81,IENG1, AVP, PL, F224	81,IENG1, AVP, PL, F224
20h-21h	65,ALGAN, MGM, T, F342	65,ALGAN, MGM, T, F342
21h-22h	65,ALGAN, MGM, T, F342	65,ALGAN, MGM, T, F342
22h-23h	71,CMATE-M, RBC, T, I301	71,CMATE-M, RBC, T, I301
23h-24h	71,CMATE-M, RBC, T, I301	71,CMATE-M, RBC, T, I301
	Qui	
18h-19h		
19h-20h	68,APROG, JSM, T, I301	68,APROG, JSM, T, I301
20h-21h	68,APROG, JSM, T, I301	68,APROG, JSM, T, I301
21h-22h	77,FSIAP, MPA, T, F342	77,FSIAP, MPA, T, F342
22h-23h	80,IENG1, LMD, T, I301	80,IENG1, LMD, T, I301
23h-24h		
	Sex	
18h-19h		
19h-20h		
20h-21h		
21h-22h		
22h-23h		
23h-24h		

LEM-N2	2NA	2NB	2NC
		Seg	
18h-19h		144,MECA2, HDA, TP, F317	141,MATE2, DC1, TP, F209
19h-20h	134,CEFAC, MOS, PL, F225	144,MECA2, HDA, TP, F317	141,MATE2, DC1, TP, F209
20h-21h	134,CEFAC, MOS, PL, F225	140,MATE2, DC1, TP, F209	145,MECA2, HDA, TP, F207
21h-22h	134,CEFAC, MOS, PL, F225	140,MATE2, DC1, TP, F209	145,MECA2, HDA, TP, F207
22h-23h	143,MECA2, HDA, TP, F202	150,TERMO, ARJ, TP, F203	150,TERMO, ARJ, TP, F203
23h-24h	143,MECA2, HDA, TP, F202	150,TERMO, ARJ, TP, F203	150,TERMO, ARJ, TP, F203
		Ter	
18h-19h	139,MATE2, SMA, TP, F202		
19h-20h	139,MATE2, SMA, TP, F202	135,CEFAC, MOS, PL, F221	135,CEFAC, MOS, PL, F221
20h-21h	149,TERMO, PAA, TP, F203	135,CEFAC, MOS, PL, F221	135,CEFAC, MOS, PL, F221
21h-22h	149,TERMO, PAA, TP, F203	135,CEFAC, MOS, PL, F221	135,CEFAC, MOS, PL, F221
22h-23h	138,MATE2, SMA, T, I201	138,MATE2, SMA, T, I201	138,MATE2, SMA, T, I201
23h-24h	138,MATE2, SMA, T, I201	138,MATE2, SMA, T, I201	138,MATE2, SMA, T, I201
		Qua	
18h-19h	137,EMELE, PMA, PL, F225	137,EMELE, PMA, PL, F225	137,EMELE, PMA, PL, F225
19h-20h	137,EMELE, PMA, PL, F225	137,EMELE, PMA, PL, F225	137,EMELE, PMA, PL, F225
20h-21h	146,MTNMT, MDC, T, F341	146,MTNMT, MDC, T, F341	146,MTNMT, MDC, T, F341
21h-22h	146,MTNMT, MDC, T, F341	146,MTNMT, MDC, T, F341	146,MTNMT, MDC, T, F341
22h-23h	147,MTNMT, PUR, TP, F208	147,MTNMT, PUR, TP, F208	147,MTNMT, PUR, TP, F208
23h-24h	147,MTNMT, PUR, TP, F208	147,MTNMT, PUR, TP, F208	147,MTNMT, PUR, TP, F208
		Qui	
18h-19h			
19h-20h	148,TERMO, PAA, T, F341	148,TERMO, PAA, T, F341	148,TERMO, PAA, T, F341
20h-21h	148,TERMO, PAA, T, F341	148,TERMO, PAA, T, F341	148,TERMO, PAA, T, F341
21h-22h	136,EMELE, ATA, T, F341	136,EMELE, ATA, T, F341	136,EMELE, ATA, T, F341
22h-23h	142,MECA2, JFJ, T, F341	142,MECA2, JFJ, T, F341	142,MECA2, JFJ, T, F341
23h-24h	142,MECA2, JFJ, T, F341	142,MECA2, JFJ, T, F341	142,MECA2, JFJ, T, F341
		Sex	
18h-19h			
19h-20h			
20h-21h			
21h-22h			
22h-23h			
23h-24h			

LEM-N3	3NA	3NB	3NC
		Seg	
18h-19h	207,PFAB2, AVP, TP, F319	207,PFAB2, AVP, TP, F319	213,TRFCA-M, CDA, TP, F207
19h-20h	207,PFAB2, AVP, TP, F319	207,PFAB2, AVP, TP, F319	213,TRFCA-M, CDA, TP, F207
20h-21h	211,TRFCA-M, CDA, TP, F204	204,ORMAQ, LAM, TP, F319	208,PFAB2, AVP, TP, F202
21h-22h	211,TRFCA-M, CDA, TP, F204	204,ORMAQ, LAM, TP, F319	208,PFAB2, AVP, TP, F202
22h-23h	203,ORMAQ, LAM, TP, F207	212,TRFCA-M, CDA, TP, F209	
23h-24h	203,ORMAQ, LAM, TP, F207	212,TRFCA-M, CDA, TP, F209	
		Ter	
18h-19h			205,ORMAQ, LAM, TP, F207
19h-20h			205,ORMAQ, LAM, TP, F207
20h-21h	201,ORGI1, JAQ, TP, F208	201,ORGI1, JAQ, TP, F208	201,ORGI1, JAQ, TP, F208
21h-22h	201,ORGI1, JAQ, TP, F208	201,ORGI1, JAQ, TP, F208	201,ORGI1, JAQ, TP, F208
22h-23h	202,ORMAQ, AJC, T, I301	202,ORMAQ, AJC, T, I301	202,ORMAQ, AJC, T, I301
23h-24h	202,ORMAQ, AJC, T, I301	202,ORMAQ, AJC, T, I301	202,ORMAQ, AJC, T, I301
		Qua	
18h-19h	200,ORGI1, LMF, T, F341	200,ORGI1, LMF, T, F341	200,ORGI1, LMF, T, F341
19h-20h	209,PROJ1, RFS, PL, F322	209,PROJ1, RFS, PL, F322	209,PROJ1, RFS, PL, F322
20h-21h	209,PROJ1, RFS, PL, F322	209,PROJ1, RFS, PL, F322	209,PROJ1, RFS, PL, F322
21h-22h	209,PROJ1, RFS, PL, F322	209,PROJ1, RFS, PL, F322	209,PROJ1, RFS, PL, F322
22h-23h	206,PFAB2, LLM, T, F341	206,PFAB2, LLM, T, F341	206,PFAB2, LLM, T, F341
23h-24h	206,PFAB2, LLM, T, F341	206,PFAB2, LLM, T, F341	206,PFAB2, LLM, T, F341
		Qui	
18h-19h	210,TRFCA-M, FAC, T, I201	210,TRFCA-M, FAC, T, I201	210,TRFCA-M, FAC, T, I201
19h-20h	210,TRFCA-M, FAC, T, I201	210,TRFCA-M, FAC, T, I201	210,TRFCA-M, FAC, T, I201
20h-21h	199,AUTO1, FIL, PL, F224	199,AUTO1, FIL, PL, F224	199,AUTO1, FIL, PL, F224
21h-22h	199,AUTO1, FIL, PL, F224	199,AUTO1, FIL, PL, F224	199,AUTO1, FIL, PL, F224
22h-23h	198,AUTO1, AFS, T, I201	198,AUTO1, AFS, T, I201	198,AUTO1, AFS, T, I201
23h-24h	198,AUTO1, AFS, T, I201	198,AUTO1, AFS, T, I201	198,AUTO1, AFS, T, I201
		Sex	
18h-19h			
19h-20h			
20h-21h			
21h-22h			
22h-23h			
23h-24h			

APPENDIX B – SCHEDULS FOR ALL CLASSROOMS CONSIDERING ONE COURSE

	F202	F203	F204	F207	F208	F209
Seg						
8h-9h	175,ORMAQ, ELZ, TP,F202, 3DH	50,FSIAP, MPA, TP,F203, 1DE	195,TRFCA-M, CMI, TP,F204, 3DF	53,FSIAP, APA, TP,F207, 1DI	163,ORGI1, ANT, TP,F208, 3DA	180,PFAB2, RPM, TP,F209, 3DC
9h-10h	175,ORMAQ, ELZ, TP,F202, 3DH	50,FSIAP, MPA, TP,F203, 1DE	195,TRFCA-M, CMI, TP,F204, 3DF	53,FSIAP, APA, TP,F207, 1DI	163,ORGI1, ANT, TP,F208, 3DA	180,PFAB2, RPM, TP,F209, 3DC
10h-11h	193,TRFCA-M, LOC, TP,F202, 3DC	178,PFAB2, RPM, TP,F203, 3DA				
11h-12h	193,TRFCA-M, LOC, TP,F202, 3DC	178,PFAB2, RPM, TP,F203, 3DA		174,ORMAQ, DPG, TP,F207, 3DG	31,DESET, RDM, TP,F208, 1DB	35,DESET, CPC, TP,F209, 1DI
12h-13h				174,ORMAQ, DPG, TP,F207, 3DG	31,DESET, RDM, TP,F208, 1DB	35,DESET, CPC, TP,F209, 1DI
13h-14h	129,TERMO, ARJ, TP,F202, 2DC	121,MTNMT, JFS, TP,F203, 2DD			108,MECA2, LAM, TP,F208, 2DA	
14h-15h	129,TERMO, ARJ, TP,F202, 2DC	121,MTNMT, JFS, TP,F203, 2DD			108,MECA2, LAM, TP,F208, 2DA	
15h-16h	122,MTNMT, AGM, TP,F202, 2DE		110,MECA2, LAM, TP,F204, 2DC			
16h-17h	122,MTNMT, AGM, TP,F202, 2DE	128,TERMO, RFR, TP,F203, 2DB	110,MECA2, LAM, TP,F204, 2DC	105,MATE2, DC1, TP,F207, 2DG		
17h-18h		128,TERMO, RFR, TP,F203, 2DB		105,MATE2, DC1, TP,F207, 2DG		
18h-19h				213,TRFCA-M, CDA, TP,F207, 3NC		141,MATE2, DC1, TP,F209, 2NC
19h-20h				213,TRFCA-M, CDA, TP,F207, 3NC		141,MATE2, DC1, TP,F209, 2NC
20h-21h	208,PFAB2, AVP, TP,F202, 3NC		211,TRFCA-M, CDA, TP,F204, 3NA	145,MECA2, HDA, TP,F207, 2NC		140,MATE2, DC1, TP,F209, 2NB
21h-22h	208,PFAB2, AVP, TP,F202, 3NC		211,TRFCA-M, CDA, TP,F204, 3NA	145,MECA2, HDA, TP,F207, 2NC		140,MATE2, DC1, TP,F209, 2NB
22h-23h	143,MECA2, HDA, TP,F202, 2NA	150,TERMO, ARJ, TP,F203, 2NB		203,ORMAQ, LAM, TP,F207, 3NA		212,TRFCA-M, CDA, TP,F209, 3NB
23h-24h	143,MECA2, HDA, TP,F202, 2NA	150,TERMO, ARJ, TP,F203, 2NB		203,ORMAQ, LAM, TP,F207, 3NA		212,TRFCA-M, CDA, TP,F209, 3NB
Ter						
8h-9h	196,TRFCA-M, LOC, TP,F202, 3DG	33,DESET, OCF, TP,F203, 1DE	171,ORMAQ, DPG, TP,F204, 3DC		34,DESET, EFM, TP,F208, 1DG	172,ORMAQ, AJC, TP,F209, 3DE
9h-10h	196,TRFCA-M, LOC, TP,F202, 3DG	33,DESET, OCF, TP,F203, 1DE	171,ORMAQ, DPG, TP,F204, 3DC		34,DESET, EFM, TP,F208, 1DG	172,ORMAQ, AJC, TP,F209, 3DE
10h-11h		166,ORGI1, ANT, TP,F203, 3DE	165,ORGI1, VEC, TP,F204, 3DC		3,ALGAN, MGM, TP,F208, 1DC	
11h-12h		166,ORGI1, ANT, TP,F203, 3DE	165,ORGI1, VEC, TP,F204, 3DC	6,ALGAN, GCV, TP,F207, 1DI	3,ALGAN, MGM, TP,F208, 1DC	182,PFAB2, RPM, TP,F209, 3DG
12h-13h				6,ALGAN, GCV, TP,F207, 1DI		182,PFAB2, RPM, TP,F209, 3DG
13h-14h	131,TERMO, RFR, TP,F202, 2DE	120,MTNMT, PUR, TP,F203, 2DC	109,MECA2, LAM, TP,F204, 2DB		132,TERMO, PAA, TP,F208, 2DF	114,MECA2, JOB, TP,F209, 2DG
14h-15h	131,TERMO, RFR, TP,F202, 2DE	120,MTNMT, PUR, TP,F203, 2DC	109,MECA2, LAM, TP,F204, 2DB		132,TERMO, PAA, TP,F208, 2DF	114,MECA2, JOB, TP,F209, 2DG
15h-16h		123,MTNMT, AGM, TP,F203, 2DF	119,MTNMT, JFS, TP,F204, 2DB	111,MECA2, JOB, TP,F207, 2DD		127,TERMO, RFR, TP,F209, 2DA
16h-17h		123,MTNMT, AGM, TP,F203, 2DF	119,MTNMT, JFS, TP,F204, 2DB	111,MECA2, JOB, TP,F207, 2DD		127,TERMO, RFR, TP,F209, 2DA
17h-18h						
18h-19h	139,MATE2, SMA, TP,F202, 2NA		67,ALGAN, GCV, TP,F204, 1NB	205,ORMAQ, LAM, TP,F207, 3NC		78,FSIAP, MPA, TP,F209, 1NA
19h-20h	139,MATE2, SMA, TP,F202, 2NA		67,ALGAN, GCV, TP,F204, 1NB	205,ORMAQ, LAM, TP,F207, 3NC		78,FSIAP, MPA, TP,F209, 1NA
20h-21h		149,TERMO, PAA, TP,F203, 2NA			201,ORGI1, JAQ, TP,F208, 3NA	
21h-22h		149,TERMO, PAA, TP,F203, 2NA			201,ORGI1, JAQ, TP,F208, 3NA	
22h-23h					74,DESET, ALS, TP,F208, 1NA	
23h-24h					74,DESET, ALS, TP,F208, 1NA	
Qua						
8h-9h	173,ORMAQ, DPG, TP,F202, 3DF	194,TRFCA-M, FAC, TP,F203, 3DE	48,FSIAP, JNP, TP,F204, 1DA		170,ORMAQ, RCM, TP,F208, 3DA	
9h-10h	173,ORMAQ, DPG, TP,F202, 3DF	194,TRFCA-M, FAC, TP,F203, 3DE	48,FSIAP, JNP, TP,F204, 1DA		170,ORMAQ, RCM, TP,F208, 3DA	
10h-11h				167,ORGI1, VEC, TP,F207, 3DG	2,ALGAN, MGM, TP,F208, 1DA	
11h-12h				167,ORGI1, VEC, TP,F207, 3DG	2,ALGAN, MGM, TP,F208, 1DA	
12h-13h						
13h-14h	101,MATE2, ASB, TP,F202, 2DA	102,MATE2, DC1, TP,F203, 2DB		112,MECA2, JOB, TP,F207, 2DE	130,TERMO, RFR, TP,F208, 2DD	
14h-15h	101,MATE2, ASB, TP,F202, 2DA	102,MATE2, DC1, TP,F203, 2DB		112,MECA2, JOB, TP,F207, 2DE	130,TERMO, RFR, TP,F208, 2DD	
15h-16h			118,MTNMT, PUR, TP,F204, 2DA	104,MATE2, DC1, TP,F207, 2DE		
16h-17h			118,MTNMT, PUR, TP,F204, 2DA	104,MATE2, DC1, TP,F207, 2DE		
17h-18h						
18h-19h						
19h-20h						
20h-21h						
21h-22h						
22h-23h					147,MTNMT, PUR, TP,F208, 2NA	
23h-24h					147,MTNMT, PUR, TP,F208, 2NA	
Qui						
8h-9h	4,ALGAN, MGM, TP,F202, 1DE		49,FSIAP, MPA, TP,F204, 1DC			
9h-10h	4,ALGAN, MGM, TP,F202, 1DE		49,FSIAP, MPA, TP,F204, 1DC			
10h-11h						
11h-12h						
12h-13h						
13h-14h						
14h-15h						
15h-16h						
16h-17h						
17h-18h						
18h-19h						
19h-20h						
20h-21h						
21h-22h						
22h-23h						
23h-24h						
Sex						
8h-9h						
9h-10h						
10h-11h						
11h-12h						
12h-13h						
13h-14h						
14h-15h						
15h-16h						
16h-17h						
17h-18h						
18h-19h						
19h-20h						
20h-21h						
21h-22h						
22h-23h						
23h-24h						

	F214	F216	F218	F221	F224	F225	F226
				Seg			
8h-9h	23,CMATE-M, FAF, PL,F214, 1DC	157,AUTO1, AFS, PL,F216, 3DE	16,APROG, AFO, PL,F218, 1DH	59,IENG1, ICT, PL,F221, 1DD	56,IENG1, SCF, PL,F224, 1DA	15,APROG, NVM, PL,F225, 1DG	37,DESET, RDM, PL,F226, 1DB
9h-10h	23,CMATE-M, FAF, PL,F214, 1DC	157,AUTO1, AFS, PL,F216, 3DE	16,APROG, AFO, PL,F218, 1DH	59,IENG1, ICT, PL,F221, 1DD	56,IENG1, SCF, PL,F224, 1DA	15,APROG, NVM, PL,F225, 1DG	37,DESET, RDM, PL,F226, 1DB
10h-11h	184,PROJ1, ISP, PL,F214, 3DB			187,PROJ1, RFS, PL,F221, 3DF		186,PROJ1, CEC, PL,F225, 3DE	
11h-12h	184,PROJ1, ISP, PL,F214, 3DB	21,CMATE-M, FAF, PL,F216, 1DA	25,CMATE-M, RBC, PL,F218, 1DE	187,PROJ1, RFS, PL,F221, 3DF	61,IENG1, IAA, PL,F224, 1DF	186,PROJ1, CEC, PL,F225, 3DE	42,DESET, EFM, PL,F226, 1DG
12h-13h	184,PROJ1, ISP, PL,F214, 3DB	21,CMATE-M, FAF, PL,F216, 1DA	25,CMATE-M, RBC, PL,F218, 1DE	187,PROJ1, RFS, PL,F221, 3DF	61,IENG1, IAA, PL,F224, 1DF	186,PROJ1, CEC, PL,F225, 3DE	42,DESET, EFM, PL,F226, 1DG
13h-14h	96,EMELE, ATA, PL,F214, 2DE				87,CEFAC, DER, PL,F224, 2DF	83,CEFAC, MON, PL,F225, 2DB	
14h-15h	96,EMELE, ATA, PL,F214, 2DE				87,CEFAC, DER, PL,F224, 2DF	83,CEFAC, MON, PL,F225, 2DB	
15h-16h	85,CEFAC, JPR, PL,F214, 2DD				87,CEFAC, DER, PL,F224, 2DF	83,CEFAC, MON, PL,F225, 2DB	82,CEFAC, ADP, PL,F226, 2DA
16h-17h	85,CEFAC, JPR, PL,F214, 2DD						82,CEFAC, ADP, PL,F226, 2DA
17h-18h	85,CEFAC, JPR, PL,F214, 2DD						82,CEFAC, ADP, PL,F226, 2DA
18h-19h	75,DESET, ALS, PL,F214, 1NA			73,CMATE-M, TSP, PL,F221, 1NB			
19h-20h	75,DESET, ALS, PL,F214, 1NA			73,CMATE-M, TSP, PL,F221, 1NB		134,CEFAC, MOS, PL,F225, 2NA	
20h-21h		70,APROG, DPP, PL,F216, 1NB	72,CMATE-M, TSP, PL,F218, 1NA			134,CEFAC, MOS, PL,F225, 2NA	
21h-22h		70,APROG, DPP, PL,F216, 1NB	72,CMATE-M, TSP, PL,F218, 1NA			134,CEFAC, MOS, PL,F225, 2NA	
22h-23h		69,APROG, DPP, PL,F216, 1NA					
23h-24h		69,APROG, DPP, PL,F216, 1NA					
				Ter			
8h-9h	153,AUTO1, PJF, PL,F214, 3DA	57,IENG1, SCF, PL,F216, 1DB	189,PROJ1, MOA, PL,F218, 3DH	44,DESET, CPC, PL,F221, 1DI	12,APROG, RAL, PL,F224, 1DD	158,AUTO1, FAL, PL,F225, 3DF	18,APROG, AFO, PL,F226, 1DJ
9h-10h	153,AUTO1, PJF, PL,F214, 3DA	57,IENG1, SCF, PL,F216, 1DB	189,PROJ1, MOA, PL,F218, 3DH	44,DESET, CPC, PL,F221, 1DI	12,APROG, RAL, PL,F224, 1DD	158,AUTO1, FAL, PL,F225, 3DF	18,APROG, AFO, PL,F226, 1DJ
10h-11h	22,CMATE-M, FAF, PL,F214, 1DB	36,DESET, AGS, PL,F216, 1DA	189,PROJ1, MOA, PL,F218, 3DH		60,IENG1, IAA, PL,F224, 1DE	183,PROJ1, ISP, PL,F225, 3DA	154,AUTO1, PJF, PL,F226, 3DB
11h-12h	22,CMATE-M, FAF, PL,F214, 1DB	36,DESET, AGS, PL,F216, 1DA	62,IENG1, SCF, PL,F218, 1DG	14,APROG, AFO, PL,F221, 1DF	60,IENG1, IAA, PL,F224, 1DE	183,PROJ1, ISP, PL,F225, 3DA	154,AUTO1, PJF, PL,F226, 3DB
12h-13h			62,IENG1, SCF, PL,F218, 1DG	14,APROG, AFO, PL,F221, 1DF		183,PROJ1, ISP, PL,F225, 3DA	
13h-14h		92,EMELE, ATA, PL,F216, 2DA	95,EMELE, PMA, PL,F218, 2DD		89,CEFAC, MMA, PL,F224, 2DH		
14h-15h		92,EMELE, ATA, PL,F216, 2DA	95,EMELE, PMA, PL,F218, 2DD		89,CEFAC, MMA, PL,F224, 2DH		
15h-16h		86,CEFAC, DER, PL,F216, 2DE		94,EMELE, ATA, PL,F221, 2DC	89,CEFAC, MMA, PL,F224, 2DH		
16h-17h		86,CEFAC, DER, PL,F216, 2DE		94,EMELE, ATA, PL,F221, 2DC			
17h-18h		86,CEFAC, DER, PL,F216, 2DE					
18h-19h							
19h-20h				135,CEFAC, MOS, PL,F221, 2NB			
20h-21h				135,CEFAC, MOS, PL,F221, 2NB			
21h-22h				135,CEFAC, MOS, PL,F221, 2NB			
22h-23h							
23h-24h							
				Qua			
8h-9h	156,AUTO1, ADS, PL,F214, 3DD	58,IENG1, ICT, PL,F216, 1DC	155,AUTO1, PJF, PL,F218, 3DC	159,AUTO1, FAL, PL,F221, 3DG	39,DESET, SCF, PL,F224, 1DD	13,APROG, EVF, PL,F225, 1DE	160,AUTO1, AFS, PL,F226, 3DH
9h-10h	156,AUTO1, ADS, PL,F214, 3DD	58,IENG1, ICT, PL,F216, 1DC	155,AUTO1, PJF, PL,F218, 3DC	159,AUTO1, FAL, PL,F221, 3DG	39,DESET, SCF, PL,F224, 1DD	13,APROG, EVF, PL,F225, 1DE	160,AUTO1, AFS, PL,F226, 3DH
10h-11h	45,DESET, CPC, PL,F214, 1DJ	17,APROG, EVF, PL,F216, 1DI	38,DESET, SCF, PL,F218, 1DC	40,DESET, OCF, PL,F221, 1DE	24,CMATE-M, FAF, PL,F224, 1DD		26,CMATE-M, SMS, PL,F226, 1DF
11h-12h	45,DESET, CPC, PL,F214, 1DJ	17,APROG, EVF, PL,F216, 1DI	38,DESET, SCF, PL,F218, 1DC	40,DESET, OCF, PL,F221, 1DE	24,CMATE-M, FAF, PL,F224, 1DD		26,CMATE-M, SMS, PL,F226, 1DF
12h-13h							
13h-14h				84,CEFAC, ADP, PL,F221, 2DC	97,EMELE, PMA, PL,F224, 2DF		
14h-15h				84,CEFAC, ADP, PL,F221, 2DC	97,EMELE, PMA, PL,F224, 2DF		
15h-16h				84,CEFAC, ADP, PL,F221, 2DC	98,EMELE, ATA, PL,F224, 2DG		
16h-17h					98,EMELE, ATA, PL,F224, 2DG		
17h-18h							
18h-19h					81,IENG1, AVP, PL,F224, 1NA	137,EMELE, PMA, PL,F225, 2NA	
19h-20h					81,IENG1, AVP, PL,F224, 1NA	137,EMELE, PMA, PL,F225, 2NA	
20h-21h							
21h-22h							
22h-23h							
23h-24h							
				Qui			
8h-9h	64,IENG1, ICT, PL,F214, 1DI	28,CMATE-M, SMS, PL,F216, 1DH			10,APROG, RAL, PL,F224, 1DB	9,APROG, JSM, PL,F225, 1DA	
9h-10h	64,IENG1, ICT, PL,F214, 1DI	28,CMATE-M, SMS, PL,F216, 1DH			10,APROG, RAL, PL,F224, 1DB	9,APROG, JSM, PL,F225, 1DA	
10h-11h							
11h-12h							
12h-13h							
13h-14h							
14h-15h							
15h-16h							
16h-17h							
17h-18h							
18h-19h							
19h-20h							
20h-21h					199,AUTO1, FIL, PL,F224, 3NA		
21h-22h					199,AUTO1, FIL, PL,F224, 3NA		
22h-23h							
23h-24h							
				Sex			
8h-9h	29,CMATE-M, SMS, PL,F214, 1DI						
9h-10h	29,CMATE-M, SMS, PL,F214, 1DI						
10h-11h							
11h-12h							
12h-13h							
13h-14h							
14h-15h							
15h-16h							
16h-17h							
17h-18h							
18h-19h							
19h-20h							
20h-21h							
21h-22h							
22h-23h							
23h-24h							

	F317	F319	F322	F341	F342	I201	I301
				Seg			
8h-9h	51,FSIAP, JNP, TP,F317, 1DF	164,ORGI1, JAQ, TP,F319, 3DB	188,PROJ1, MOA, PL,F322, 3DG				
9h-10h	51,FSIAP, JNP, TP,F317, 1DF	164,ORGI1, JAQ, TP,F319, 3DB	188,PROJ1, MOA, PL,F322, 3DG				
10h-11h	197,TRFCA-M, CMI, TP,F317, 3DH		188,PROJ1, MOA, PL,F322, 3DG	54,IENG1, LMD, T,F341, 1DA		47,FSIAP, MPA, T,I201, 1DF	
11h-12h	197,TRFCA-M, CMI, TP,F317, 3DH	32,DESET, SCF, TP,F319, 1DC	63,IENG1, ICT, PL,F322, 1DH				
12h-13h		32,DESET, SCF, TP,F319, 1DC	63,IENG1, ICT, PL,F322, 1DH				
13h-14h	115,MECA2, REM, TP,F317, 2DH		88,CEFAC, MMA, PL,F322, 2DG				
14h-15h	115,MECA2, REM, TP,F317, 2DH		88,CEFAC, MMA, PL,F322, 2DG				
15h-16h			88,CEFAC, MMA, PL,F322, 2DG				
16h-17h	113,MECA2, JOB, TP,F317, 2DF						
17h-18h	113,MECA2, JOB, TP,F317, 2DF						
18h-19h	144,MECA2, HDA, TP,F317, 2NB	207,PFAB2, AVP, TP,F319, 3NA					
19h-20h	144,MECA2, HDA, TP,F317, 2NB	207,PFAB2, AVP, TP,F319, 3NA					
20h-21h		204,ORMAQ, LAM, TP,F319, 3NB					
21h-22h		204,ORMAQ, LAM, TP,F319, 3NB					
22h-23h	79,FSIAP, MPA, TP,F317, 1NB						
23h-24h	79,FSIAP, MPA, TP,F317, 1NB						
				Ter			
8h-9h	30,DESET, AGS, TP,F317, 1DA	179,PFAB2, RPM, TP,F319, 3DB	11,APROG, JSM, PL,F322, 1DC				
9h-10h	30,DESET, AGS, TP,F317, 1DA	179,PFAB2, RPM, TP,F319, 3DB	11,APROG, JSM, PL,F322, 1DC				
10h-11h							55,IENG1, LMD, T,I301, 1DF
11h-12h			43,DESET, EFM, PL,F322, 1DH				
12h-13h			43,DESET, EFM, PL,F322, 1DH				46,FSIAP, MPA, T,I301, 1DA
13h-14h							
14h-15h							
15h-16h							
16h-17h		133,TERMO, PAA, TP,F319, 2DG					
17h-18h		133,TERMO, PAA, TP,F319, 2DG			90,EMELE, ATA, T,F342, 2DA		
18h-19h							
19h-20h							
20h-21h	66,ALGAN, MGM, TP,F317, 1NA		76,DESET, ALS, PL,F322, 1NB				
21h-22h	66,ALGAN, MGM, TP,F317, 1NA		76,DESET, ALS, PL,F322, 1NB				
22h-23h						138,MATE2, SMA, T,I201, 2NA	202,ORMAQ, AJC, T,I301, 3NA
23h-24h						138,MATE2, SMA, T,I201, 2NA	202,ORMAQ, AJC, T,I301, 3NA
				Qua			
8h-9h			41,DESET, OCF, PL,F322, 1DF			1,ALGAN, MGM, T,I201, 1DG	
9h-10h			41,DESET, OCF, PL,F322, 1DF			1,ALGAN, MGM, T,I201, 1DG	
10h-11h	181,PFAB2, RPM, TP,F317, 3DE	5,ALGAN, GCV, TP,F319, 1DG			161,ORGI1, LMF, T,F342, 3DA		
11h-12h	181,PFAB2, RPM, TP,F317, 3DE	5,ALGAN, GCV, TP,F319, 1DG					190,TRFCA-M, FAC, T,I301, 3DA
12h-13h						162,ORGI1, LMF, T,I201, 3DE	190,TRFCA-M, FAC, T,I301, 3DA
13h-14h	124,MTNMT, PUR, TP,F317, 2DG						
14h-15h	124,MTNMT, PUR, TP,F317, 2DG						
15h-16h			93,EMELE, PMA, PL,F322, 2DB				
16h-17h		103,MATE2, ASB, TP,F319, 2DC	93,EMELE, PMA, PL,F322, 2DB				
17h-18h		103,MATE2, ASB, TP,F319, 2DC					91,EMELE, ATA, T,I301, 2DE
18h-19h				200,ORGI1, LMF, T,F341, 3NA			
19h-20h			209,PROJ1, RFS, PL,F322, 3NA				
20h-21h			209,PROJ1, RFS, PL,F322, 3NA	146,MTNMT, MDC, T,F341, 2NA	65,ALGAN, MGM, T,F342, 1NA		
21h-22h			209,PROJ1, RFS, PL,F322, 3NA	146,MTNMT, MDC, T,F341, 2NA	65,ALGAN, MGM, T,F342, 1NA		
22h-23h				206,PFAB2, LLM, T,F341, 3NA			71,CMATE-M, RBC, T,I301, 1NA
23h-24h				206,PFAB2, LLM, T,F341, 3NA			71,CMATE-M, RBC, T,I301, 1NA
				Qui			
8h-9h			27,CMATE-M, PPS, PL,F322, 1DG	191,TRFCA-M, LOC, T,F341, 3DE			151,AUTO1, AFS, T,I301, 3DA
9h-10h			27,CMATE-M, PPS, PL,F322, 1DG	191,TRFCA-M, LOC, T,F341, 3DE			151,AUTO1, AFS, T,I301, 3DA
10h-11h	192,TRFCA-M, LOC, TP,F317, 3DA		185,PROJ1, VHN, PL,F322, 3DC	7,APROG, JSM, T,F341, 1DA	20,CMATE-M, RBC, T,F342, 1DF	177,PFAB2, RPM, T,I201, 3DE	
11h-12h	192,TRFCA-M, LOC, TP,F317, 3DA		185,PROJ1, VHN, PL,F322, 3DC	7,APROG, JSM, T,F341, 1DA	20,CMATE-M, RBC, T,F342, 1DF	177,PFAB2, RPM, T,I201, 3DE	
12h-13h			185,PROJ1, VHN, PL,F322, 3DC				
13h-14h				125,TERMO, PAA, T,F341, 2DA			107,MECA2, JFJ, T,I301, 2DE
14h-15h				125,TERMO, PAA, T,F341, 2DA			107,MECA2, JFJ, T,I301, 2DE
15h-16h				106,MECA2, JFJ, T,F341, 2DA	126,TERMO, PAA, T,F342, 2DE		
16h-17h				106,MECA2, JFJ, T,F341, 2DA	126,TERMO, PAA, T,F342, 2DE		
17h-18h							
18h-19h						210,TRFCA-M, FAC, T,I201, 3NA	
19h-20h				148,TERMO, PAA, T,F341, 2NA		210,TRFCA-M, FAC, T,I201, 3NA	68,APROG, JSM, T,I301, 1NA
20h-21h				148,TERMO, PAA, T,F341, 2NA			68,APROG, JSM, T,I301, 1NA
21h-22h				136,EMELE, ATA, T,F341, 2NA	77,FSIAP, MPA, T,F342, 1NA		
22h-23h				142,MECA2, JFJ, T,F341, 2NA		198,AUTO1, AFS, T,I201, 3NA	80,IENG1, LMD, T,I301, 1NA
23h-24h				142,MECA2, JFJ, T,F341, 2NA		198,AUTO1, AFS, T,I201, 3NA	
				Sex			
8h-9h		52,FSIAP, APA, TP,F319, 1DG		168,ORMAQ, AJC, T,F341, 3DA		169,ORMAQ, JSB, T,I201, 3DE	0,ALGAN, MGM, T,I301, 1DA
9h-10h		52,FSIAP, APA, TP,F319, 1DG		168,ORMAQ, AJC, T,F341, 3DA		169,ORMAQ, JSB, T,I201, 3DE	0,ALGAN, MGM, T,I301, 1DA
10h-11h				8,APROG, JSM, T,F341, 1DF	176,PFAB2, LLM, T,F342, 3DA	152,AUTO1, ADS, T,I201, 3DE	19,CMATE-M, RBC, T,I301, 1DA
11h-12h				8,APROG, JSM, T,F341, 1DF	176,PFAB2, LLM, T,F342, 3DA	152,AUTO1, ADS, T,I201, 3DE	19,CMATE-M, RBC, T,I301, 1DA
12h-13h							
13h-14h					116,MTNMT, MDC, T,F342, 2DA		100,MATE2, ASB, T,I301, 2DE
14h-15h					116,MTNMT, MDC, T,F342, 2DA		100,MATE2, ASB, T,I301, 2DE
15h-16h				117,MTNMT, AGM, T,F341, 2DE		99,MATE2, ASB, T,I201, 2DA	
16h-17h				117,MTNMT, AGM, T,F341, 2DE		99,MATE2, ASB, T,I201, 2DA	
17h-18h							
18h-19h							
19h-20h							
20h-21h							
21h-22h							
22h-23h							
23h-24h							

APPENDIX C – SCHEDULS FOR ALL GROUPS OF STUDENTS CONSIDERING TWO COURSES

LEM_D1	1DA	1DB	1DC	1DD	1DE	1DF	1DG	1DH	1DI	1DJ
Seg										
8h-9h	21,CMATE-M, FAF, PL, F322	37,DESET, RDM, PL, Z12	49,FSIAP, MPA, TP, F208	49,FSIAP, MPA, TP, F208	60,IENG1, IAA, PL, F218	41,DESET, OCF, PL, Z14	62,IENG1, SCF, PL, F224	43,DESET, EFM, PL, Z15		
9h-10h	21,CMATE-M, FAF, PL, F322	37,DESET, RDM, PL, Z12	49,FSIAP, MPA, TP, F208	49,FSIAP, MPA, TP, F208	60,IENG1, IAA, PL, F218	41,DESET, OCF, PL, Z14	62,IENG1, SCF, PL, F224	43,DESET, EFM, PL, Z15	44,DESET, CPC, PL, Z17	18,APROG, AFO, PL, F226
10h-11h	46,FSIAP, MPA, T, F342	46,FSIAP, MPA, T, F342	46,FSIAP, MPA, T, F342	46,FSIAP, MPA, T, F342	46,FSIAP, MPA, T, F342	61,IENG1, IAA, PL, Z12			44,DESET, CPC, PL, Z17	18,APROG, AFO, PL, F226
11h-12h	56,IENG1, SCF, PL, Z13	31,DESET, RDM, TP, Z09	58,IENG1, ICT, PL, Z17	24,CMATE-M, FAF, PL, F224	50,FSIAP, MPA, TP, F319	61,IENG1, IAA, PL, Z12	27,CMATE-M, PPS, PL, Z14	28,CMATE-M, SMS, PL, F221	53,FSIAP, APA, TP, Z10	53,FSIAP, APA, TP, Z10
12h-13h	56,IENG1, SCF, PL, Z13	31,DESET, RDM, TP, Z09	58,IENG1, ICT, PL, Z17	24,CMATE-M, FAF, PL, F224	50,FSIAP, MPA, TP, F319		27,CMATE-M, PPS, PL, Z14	28,CMATE-M, SMS, PL, F221	53,FSIAP, APA, TP, Z10	53,FSIAP, APA, TP, Z10
Ter										
8h-9h	48,FSIAP, JNP, TP, F207	48,FSIAP, JNP, TP, F207	3,ALGAN, MGM, TP, Z11	3,ALGAN, MGM, TP, Z11	40,DESET, OCF, PL, F221	26,CMATE-M, SMS, PL, Z14	42,DESET, EFM, PL, F216	16,APROG, AFO, PL, F225	6,ALGAN, GCV, TP, F202	6,ALGAN, GCV, TP, F202
9h-10h	48,FSIAP, JNP, TP, F207	48,FSIAP, JNP, TP, F207	3,ALGAN, MGM, TP, Z11	3,ALGAN, MGM, TP, Z11	40,DESET, OCF, PL, F221	26,CMATE-M, SMS, PL, Z14	42,DESET, EFM, PL, F216	16,APROG, AFO, PL, F225	6,ALGAN, GCV, TP, F202	6,ALGAN, GCV, TP, F202
10h-11h	54,IENG1, LMD, T, I201	54,IENG1, LMD, T, I201	54,IENG1, LMD, T, I201	54,IENG1, LMD, T, I201	54,IENG1, LMD, T, I201	47,FSIAP, MPA, T, F341	47,FSIAP, MPA, T, F341	47,FSIAP, MPA, T, F341	47,FSIAP, MPA, T, F341	47,FSIAP, MPA, T, F341
11h-12h	30,DESET, AGS, TP, Z06	57,IENG1, SCF, PL, F221	23,CMATE-M, FAF, PL, F214	12,APROG, RAL, PL, Z13	4,ALGAN, MGM, TP, F208	4,ALGAN, MGM, TP, F208	15,APROG, NVM, PL, F216	63,IENG1, ICT, PL, Z17	29,CMATE-M, SMS, PL, F226	29,CMATE-M, SMS, PL, F226
12h-13h	30,DESET, AGS, TP, Z06	57,IENG1, SCF, PL, F221	23,CMATE-M, FAF, PL, F214	12,APROG, RAL, PL, Z13	4,ALGAN, MGM, TP, F208	4,ALGAN, MGM, TP, F208	15,APROG, NVM, PL, F216	63,IENG1, ICT, PL, Z17	29,CMATE-M, SMS, PL, F226	29,CMATE-M, SMS, PL, F226
Qua										
8h-9h	2,ALGAN, MGM, TP, F209	2,ALGAN, MGM, TP, F209	32,DESET, SCF, TP, F317	32,DESET, SCF, TP, F317	13,APROG, EVF, PL, F216	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342
9h-10h	2,ALGAN, MGM, TP, F209	2,ALGAN, MGM, TP, F209	32,DESET, SCF, TP, F317	32,DESET, SCF, TP, F317	13,APROG, EVF, PL, F216	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342	20,CMATE-M, RBC, T, F342
10h-11h			11,APROG, JSM, PL, Z16			55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301	55,IENG1, LMD, T, I301
11h-12h	36,DESET, AGS, PL, F226	22,CMATE-M, FAF, PL, Z12	11,APROG, JSM, PL, Z16	39,DESET, SCF, PL, Z15	25,CMATE-M, RBC, PL, F225	14,APROG, AFO, PL, Z14	5,ALGAN, GCV, TP, F207	5,ALGAN, GCV, TP, F207	17,APROG, EVF, PL, F218	45,DESET, CPC, PL, Z18
12h-13h	36,DESET, AGS, PL, F226	22,CMATE-M, FAF, PL, Z12		39,DESET, SCF, PL, Z15	25,CMATE-M, RBC, PL, F225	14,APROG, AFO, PL, Z14	5,ALGAN, GCV, TP, F207	5,ALGAN, GCV, TP, F207	17,APROG, EVF, PL, F218	45,DESET, CPC, PL, Z18
Qui										
8h-9h	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341
9h-10h	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	19,CMATE-M, RBC, T, Z04	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341	8,APROG, JSM, T, F341
10h-11h						51,FSIAP, JNP, TP, Z08	52,FSIAP, APA, TP, Z09	52,FSIAP, APA, TP, Z09		
11h-12h	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	51,FSIAP, JNP, TP, Z08	52,FSIAP, APA, TP, Z09	52,FSIAP, APA, TP, Z09	35,DESET, CPC, TP, F203	35,DESET, CPC, TP, F203
12h-13h	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03	7,APROG, JSM, T, Z03				35,DESET, CPC, TP, F203	35,DESET, CPC, TP, F203
Sex										
8h-9h	9,APROG, JSM, PL, Z12	10,APROG, RAL, PL, Z16	38,DESET, SCF, PL, F224	59,IENG1, ICT, PL, F226	33,DESET, OCF, TP, Z11	33,DESET, OCF, TP, Z11	1,ALGAN, MGM, T, Z03	1,ALGAN, MGM, T, Z03	1,ALGAN, MGM, T, Z03	1,ALGAN, MGM, T, Z03
9h-10h	9,APROG, JSM, PL, Z12	10,APROG, RAL, PL, Z16	38,DESET, SCF, PL, F224	59,IENG1, ICT, PL, F226	33,DESET, OCF, TP, Z11	33,DESET, OCF, TP, Z11	1,ALGAN, MGM, T, Z03	1,ALGAN, MGM, T, Z03	1,ALGAN, MGM, T, Z03	1,ALGAN, MGM, T, Z03
10h-11h									64,IENG1, ICT, PL, Z19	64,IENG1, ICT, PL, Z19
11h-12h	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	34,DESET, EFM, TP, F203	34,DESET, EFM, TP, F203	64,IENG1, ICT, PL, Z19	64,IENG1, ICT, PL, Z19
12h-13h	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	0,ALGAN, MGM, T, Z03	34,DESET, EFM, TP, F203	34,DESET, EFM, TP, F203		

LEM_D2	2DA	2DB	2DC	2DD	2DE	2DF	2DG	2DH
	Seg							
13h-14h	127,TERMO, RFR, TP, Z07	102,MATE2, DC1, TP, F204	84,CEFAC, ADP, PL, Z19	95,EMELE, PMA, PL, F221	86,CEFAC, DER, PL, F322	132,TERMO, PAA, TP, Z10	114,MECA2, JOB, TP, F317	89,CEFAC, MMA, PL, Z16
14h-15h	127,TERMO, RFR, TP, Z07	102,MATE2, DC1, TP, F204	84,CEFAC, ADP, PL, Z19	95,EMELE, PMA, PL, F221	86,CEFAC, DER, PL, F322	132,TERMO, PAA, TP, Z10	114,MECA2, JOB, TP, F317	89,CEFAC, MMA, PL, Z16
15h-16h	108,MECA2, LAM, TP, F317	128,TERMO, RFR, TP, F207	84,CEFAC, ADP, PL, Z19	85,CEFAC, JPR, PL, F214	86,CEFAC, DER, PL, F322	113,MECA2, JOB, TP, Z09		89,CEFAC, MMA, PL, Z16
16h-17h	108,MECA2, LAM, TP, F317	128,TERMO, RFR, TP, F207	94,EMELE, ATA, PL, Z12	85,CEFAC, JPR, PL, F214	122,MTNMT, AGM, TP, F208	113,MECA2, JOB, TP, Z09	105,MATE2, DC1, TP, F209	105,MATE2, DC1, TP, F209
17h-18h			94,EMELE, ATA, PL, Z12	85,CEFAC, JPR, PL, F214	122,MTNMT, AGM, TP, F208		105,MATE2, DC1, TP, F209	105,MATE2, DC1, TP, F209
	Ter							
13h-14h	118,MTNMT, PUR, TP, F208	83,CEFAC, MON, PL, F322	129,TERMO, ARJ, TP, F207	130,TERMO, RFR, TP, Z07	112,MECA2, JOB, TP, F317	97,EMELE, PMA, PL, F218	88,CEFAC, MMA, PL, Z14	115,MECA2, REM, TP, F209
14h-15h	118,MTNMT, PUR, TP, F208	83,CEFAC, MON, PL, F322	129,TERMO, ARJ, TP, F207	130,TERMO, RFR, TP, Z07	112,MECA2, JOB, TP, F317	97,EMELE, PMA, PL, F218	88,CEFAC, MMA, PL, Z14	115,MECA2, REM, TP, F209
15h-16h	82,CEFAC, ADP, PL, F226	83,CEFAC, MON, PL, F322	110,MECA2, LAM, TP, Z07	111,MECA2, JOB, TP, F204	131,TERMO, RFR, TP, Z06	87,CEFAC, DER, PL, F216	88,CEFAC, MMA, PL, Z14	
16h-17h	82,CEFAC, ADP, PL, F226	119,MTNMT, JFS, TP, F317	110,MECA2, LAM, TP, Z07	111,MECA2, JOB, TP, F204	131,TERMO, RFR, TP, Z06	87,CEFAC, DER, PL, F216	98,EMELE, ATA, PL, F221	98,EMELE, ATA, PL, F221
17h-18h	82,CEFAC, ADP, PL, F226	119,MTNMT, JFS, TP, F317				87,CEFAC, DER, PL, F216	98,EMELE, ATA, PL, F221	98,EMELE, ATA, PL, F221
	Qua							
13h-14h	101,MATE2, ASB, TP, F207	93,EMELE, PMA, PL, F214	120,MTNMT, PUR, TP, Z05	121,MTNMT, JFS, TP, F317	96,EMELE, ATA, PL, F226		133,TERMO, PAA, TP, F208	133,TERMO, PAA, TP, F208
14h-15h	101,MATE2, ASB, TP, F207	93,EMELE, PMA, PL, F214	120,MTNMT, PUR, TP, Z05	121,MTNMT, JFS, TP, F317	96,EMELE, ATA, PL, F226	123,MTNMT, AGM, TP, Z11	133,TERMO, PAA, TP, F208	133,TERMO, PAA, TP, F208
15h-16h	90,EMELE, ATA, T, I301	90,EMELE, ATA, T, I301	90,EMELE, ATA, T, I301	90,EMELE, ATA, T, I301		123,MTNMT, AGM, TP, Z11		
16h-17h	92,EMELE, ATA, PL, Z15	109,MECA2, LAM, TP, F317	103,MATE2, ASB, TP, Z10	103,MATE2, ASB, TP, Z10	107,MECA2, JFJ, T, Z04	107,MECA2, JFJ, T, Z04	107,MECA2, JFJ, T, Z04	107,MECA2, JFJ, T, Z04
17h-18h	92,EMELE, ATA, PL, Z15	109,MECA2, LAM, TP, F317	103,MATE2, ASB, TP, Z10	103,MATE2, ASB, TP, Z10	107,MECA2, JFJ, T, Z04	107,MECA2, JFJ, T, Z04	107,MECA2, JFJ, T, Z04	107,MECA2, JFJ, T, Z04
	Qui							
13h-14h	116,MTNMT, MDC, T, I201	116,MTNMT, MDC, T, I201	116,MTNMT, MDC, T, I201	116,MTNMT, MDC, T, I201	104,MATE2, DC1, TP, F317	104,MATE2, DC1, TP, F317	124,MTNMT, PUR, TP, F208	124,MTNMT, PUR, TP, F208
14h-15h	116,MTNMT, MDC, T, I201	116,MTNMT, MDC, T, I201	116,MTNMT, MDC, T, I201	116,MTNMT, MDC, T, I201	104,MATE2, DC1, TP, F317	104,MATE2, DC1, TP, F317	124,MTNMT, PUR, TP, F208	124,MTNMT, PUR, TP, F208
15h-16h					117,MTNMT, AGM, T, Z01	117,MTNMT, AGM, T, Z01	117,MTNMT, AGM, T, Z01	117,MTNMT, AGM, T, Z01
16h-17h	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	117,MTNMT, AGM, T, Z01	117,MTNMT, AGM, T, Z01	117,MTNMT, AGM, T, Z01	117,MTNMT, AGM, T, Z01
17h-18h	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201	99,MATE2, ASB, T, I201				
	Sex							
13h-14h	125,TERMO, PAA, T, Z04	125,TERMO, PAA, T, Z04	125,TERMO, PAA, T, Z04	125,TERMO, PAA, T, Z04	91,EMELE, ATA, T, Z02	91,EMELE, ATA, T, Z02	91,EMELE, ATA, T, Z02	91,EMELE, ATA, T, Z02
14h-15h	125,TERMO, PAA, T, Z04	125,TERMO, PAA, T, Z04	125,TERMO, PAA, T, Z04	125,TERMO, PAA, T, Z04	100,MATE2, ASB, T, Z02	100,MATE2, ASB, T, Z02	100,MATE2, ASB, T, Z02	100,MATE2, ASB, T, Z02
15h-16h	106,MECA2, JFJ, T, Z01	106,MECA2, JFJ, T, Z01	106,MECA2, JFJ, T, Z01	106,MECA2, JFJ, T, Z01	100,MATE2, ASB, T, Z02	100,MATE2, ASB, T, Z02	100,MATE2, ASB, T, Z02	100,MATE2, ASB, T, Z02
16h-17h	106,MECA2, JFJ, T, Z01	106,MECA2, JFJ, T, Z01	106,MECA2, JFJ, T, Z01	106,MECA2, JFJ, T, Z01	126,TERMO, PAA, T, I301	126,TERMO, PAA, T, I301	126,TERMO, PAA, T, I301	126,TERMO, PAA, T, I301
17h-18h					126,TERMO, PAA, T, I301	126,TERMO, PAA, T, I301	126,TERMO, PAA, T, I301	126,TERMO, PAA, T, I301

LEM_D3	3DA	3DB	3DC	3DD	3DE	3DF	3DG	3DH
					Seg			
8h-9h	183,PROJ1, ISP, PL, F214	154,AUTO1, PJF, PL, F216	171,ORMAQ, DPG, TP, F319	171,ORMAQ, DPG, TP, F319	186,PROJ1, CEC, PL, F225	195,TRFCA-M, CMI, TP, F207	196,TRFCA-M, LOC, TP, F204	175,ORMAQ, ELZ, TP, Z09
9h-10h	183,PROJ1, ISP, PL, F214	154,AUTO1, PJF, PL, F216	171,ORMAQ, DPG, TP, F319	171,ORMAQ, DPG, TP, F319	186,PROJ1, CEC, PL, F225	195,TRFCA-M, CMI, TP, F207	196,TRFCA-M, LOC, TP, F204	175,ORMAQ, ELZ, TP, Z09
10h-11h	183,PROJ1, ISP, PL, F214	179,PFAB2, RPM, TP, F317	185,PROJ1, VHN, PL, F218	185,PROJ1, VHN, PL, F218	186,PROJ1, CEC, PL, F225	187,PROJ1, RFS, PL, Z18	174,ORMAQ, DPG, TP, Z08	189,PROJ1, MOA, PL, Z16
11h-12h	163,ORGI1, ANT, TP, Z07	179,PFAB2, RPM, TP, F317	185,PROJ1, VHN, PL, F218	185,PROJ1, VHN, PL, F218	172,ORMAQ, AJC, TP, Z11	187,PROJ1, RFS, PL, Z18	174,ORMAQ, DPG, TP, Z08	189,PROJ1, MOA, PL, Z16
12h-13h	163,ORGI1, ANT, TP, Z07		185,PROJ1, VHN, PL, F218	185,PROJ1, VHN, PL, F218	172,ORMAQ, AJC, TP, Z11	187,PROJ1, RFS, PL, Z18		189,PROJ1, MOA, PL, Z16
					Ter			
8h-9h	178,PFAB2, RPM, TP, F203	164,ORGI1, JAQ, TP, F317	155,AUTO1, PJF, PL, F322	156,AUTO1, ADS, PL, Z17	157,AUTO1, AFS, PL, F224	173,ORMAQ, DPG, TP, F319	188,PROJ1, MOA, PL, F226	197,TRFCA-M, CMI, TP, Z08
9h-10h	178,PFAB2, RPM, TP, F203	164,ORGI1, JAQ, TP, F317	155,AUTO1, PJF, PL, F322	156,AUTO1, ADS, PL, Z17	157,AUTO1, AFS, PL, F224	173,ORMAQ, DPG, TP, F319	188,PROJ1, MOA, PL, F226	197,TRFCA-M, CMI, TP, Z08
10h-11h	161,ORGI1, LMF, T, I301	161,ORGI1, LMF, T, I301	161,ORGI1, LMF, T, I301	161,ORGI1, LMF, T, I301	166,ORGI1, ANT, TP, F317	166,ORGI1, ANT, TP, F317	188,PROJ1, MOA, PL, F226	
11h-12h	170,ORMAQ, RCM, TP, F319	170,ORMAQ, RCM, TP, F319	180,PFAB2, RPM, TP, F202	180,PFAB2, RPM, TP, F202	166,ORGI1, ANT, TP, F317	166,ORGI1, ANT, TP, F317	159,AUTO1, FAL, PL, Z12	160,AUTO1, AFS, PL, Z14
12h-13h	170,ORMAQ, RCM, TP, F319	170,ORMAQ, RCM, TP, F319	180,PFAB2, RPM, TP, F202	180,PFAB2, RPM, TP, F202			159,AUTO1, FAL, PL, Z12	160,AUTO1, AFS, PL, Z14
					Qua			
8h-9h	192,TRFCA-M, LOC, TP, Z08	192,TRFCA-M, LOC, TP, Z08	165,ORGI1, VEC, TP, F207	165,ORGI1, VEC, TP, F207	194,TRFCA-M, FAC, TP, Z11	158,AUTO1, FAL, PL, Z12	182,PFAB2, RPM, TP, F202	182,PFAB2, RPM, TP, F202
9h-10h	192,TRFCA-M, LOC, TP, Z08	192,TRFCA-M, LOC, TP, Z08	165,ORGI1, VEC, TP, F207	165,ORGI1, VEC, TP, F207	194,TRFCA-M, FAC, TP, Z11	158,AUTO1, FAL, PL, Z12	182,PFAB2, RPM, TP, F202	182,PFAB2, RPM, TP, F202
10h-11h	176,PFAB2, LLM, T, Z04	176,PFAB2, LLM, T, Z04	176,PFAB2, LLM, T, Z04	176,PFAB2, LLM, T, Z04	162,ORGI1, LMF, T, F341	162,ORGI1, LMF, T, F341	162,ORGI1, LMF, T, F341	162,ORGI1, LMF, T, F341
11h-12h	176,PFAB2, LLM, T, Z04	176,PFAB2, LLM, T, Z04	176,PFAB2, LLM, T, Z04	176,PFAB2, LLM, T, Z04	177,PFAB2, RPM, T, F341	177,PFAB2, RPM, T, F341	177,PFAB2, RPM, T, F341	177,PFAB2, RPM, T, F341
12h-13h					177,PFAB2, RPM, T, F341	177,PFAB2, RPM, T, F341	177,PFAB2, RPM, T, F341	177,PFAB2, RPM, T, F341
					Qui			
8h-9h	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	191,TRFCA-M, LOC, T, I201	191,TRFCA-M, LOC, T, I201	191,TRFCA-M, LOC, T, I201	191,TRFCA-M, LOC, T, I201
9h-10h	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	190,TRFCA-M, FAC, T, I301	191,TRFCA-M, LOC, T, I201	191,TRFCA-M, LOC, T, I201	191,TRFCA-M, LOC, T, I201	191,TRFCA-M, LOC, T, I201
10h-11h		184,PROJ1, ISP, PL, Z17						
11h-12h	153,AUTO1, PJF, PL, F224	184,PROJ1, ISP, PL, Z17	193,TRFCA-M, LOC, TP, F208	193,TRFCA-M, LOC, TP, F208	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201
12h-13h	153,AUTO1, PJF, PL, F224	184,PROJ1, ISP, PL, Z17	193,TRFCA-M, LOC, TP, F208	193,TRFCA-M, LOC, TP, F208	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201	169,ORMAQ, JSB, T, I201
					Sex			
8h-9h	151,AUTO1, AFS, T, Z04	151,AUTO1, AFS, T, Z04	151,AUTO1, AFS, T, Z04	151,AUTO1, AFS, T, Z04	181,PFAB2, RPM, TP, F203	181,PFAB2, RPM, TP, F203	167,ORGI1, VEC, TP, F317	167,ORGI1, VEC, TP, F317
9h-10h	151,AUTO1, AFS, T, Z04	151,AUTO1, AFS, T, Z04	151,AUTO1, AFS, T, Z04	151,AUTO1, AFS, T, Z04	181,PFAB2, RPM, TP, F203	181,PFAB2, RPM, TP, F203	167,ORGI1, VEC, TP, F317	167,ORGI1, VEC, TP, F317
10h-11h	168,ORMAQ, AJC, T, I201	168,ORMAQ, AJC, T, I201	168,ORMAQ, AJC, T, I201	168,ORMAQ, AJC, T, I201	152,AUTO1, ADS, T, Z02	152,AUTO1, ADS, T, Z02	152,AUTO1, ADS, T, Z02	152,AUTO1, ADS, T, Z02
11h-12h	168,ORMAQ, AJC, T, I201	168,ORMAQ, AJC, T, I201	168,ORMAQ, AJC, T, I201	168,ORMAQ, AJC, T, I201	152,AUTO1, ADS, T, Z02	152,AUTO1, ADS, T, Z02	152,AUTO1, ADS, T, Z02	152,AUTO1, ADS, T, Z02
12h-13h								

LEM_N1	1NA	1NB
	Seg	
18h-19h	75,DESET, ALS, PL, F216	73,CMATE-M, TSP, PL, F225
18h-19h	75,DESET, ALS, PL, F216	73,CMATE-M, TSP, PL, F225
20h-21h	78,FSIAP, MPA, TP, Z07	76,DESET, ALS, PL, F225
21h-22h	78,FSIAP, MPA, TP, Z07	76,DESET, ALS, PL, F225
22h-23h	66,ALGAN, MGM, TP, F204	79,FSIAP, MPA, TP, Z05
23h-24h	66,ALGAN, MGM, TP, F204	79,FSIAP, MPA, TP, Z05
	Ter	
18h-19h	77,FSIAP, MPA, T, Z02	77,FSIAP, MPA, T, Z02
19h-20h	72,CMATE-M, TSP, PL, Z18	70,APROG, DPP, PL, Z13
20h-21h	72,CMATE-M, TSP, PL, Z18	70,APROG, DPP, PL, Z13
21h-22h	69,APROG, DPP, PL, Z15	67,ALGAN, GCV, TP, F319
22h-23h	69,APROG, DPP, PL, Z15	67,ALGAN, GCV, TP, F319
23h-24h	80,IENG1, LMD, T, Z02	80,IENG1, LMD, T, Z02
	Qua	
18h-19h	81,IENG1, AVP, PL, F225	81,IENG1, AVP, PL, F225
19h-20h	81,IENG1, AVP, PL, F225	81,IENG1, AVP, PL, F225
20h-21h	74,DESET, ALS, TP, F203	74,DESET, ALS, TP, F203
21h-22h	74,DESET, ALS, TP, F203	74,DESET, ALS, TP, F203
22h-23h	65,ALGAN, MGM, T, I301	65,ALGAN, MGM, T, I301
23h-24h	65,ALGAN, MGM, T, I301	65,ALGAN, MGM, T, I301
	Qui	
18h-19h	68,APROG, JSM, T, Z01	68,APROG, JSM, T, Z01
19h-20h	68,APROG, JSM, T, Z01	68,APROG, JSM, T, Z01
20h-21h	71,CMATE-M, RBC, T, I201	71,CMATE-M, RBC, T, I201
21h-22h	71,CMATE-M, RBC, T, I201	71,CMATE-M, RBC, T, I201
22h-23h		
23h-24h		
	Sex	
18h-19h		
19h-20h		
20h-21h		
21h-22h		
22h-23h		
23h-24h		

LEM_N2	2NA	2NB	2NC
		Seg	
18h-19h		135,CEFAC, MOS, PL, Z16	135,CEFAC, MOS, PL, Z16
19h-20h	139,MATE2, SMA, TP, Z09	135,CEFAC, MOS, PL, Z16	135,CEFAC, MOS, PL, Z16
20h-21h	139,MATE2, SMA, TP, Z09	135,CEFAC, MOS, PL, Z16	135,CEFAC, MOS, PL, Z16
21h-22h	134,CEFAC, MOS, PL, Z16	140,MATE2, DC1, TP, F208	145,MECA2, HDA, TP, Z11
22h-23h	134,CEFAC, MOS, PL, Z16	140,MATE2, DC1, TP, F208	145,MECA2, HDA, TP, Z11
23h-24h	134,CEFAC, MOS, PL, Z16		
		Ter	
18h-19h			
19h-20h	149,TERMO, PAA, TP, F209	144,MECA2, HDA, TP, F319	141,MATE2, DC1, TP, Z06
20h-21h	149,TERMO, PAA, TP, F209	144,MECA2, HDA, TP, F319	141,MATE2, DC1, TP, Z06
21h-22h	136,EMELE, ATA, T, Z04	136,EMELE, ATA, T, Z04	136,EMELE, ATA, T, Z04
22h-23h	143,MECA2, HDA, TP, F203	150,TERMO, ARJ, TP, Z09	150,TERMO, ARJ, TP, Z09
23h-24h	143,MECA2, HDA, TP, F203	150,TERMO, ARJ, TP, Z09	150,TERMO, ARJ, TP, Z09
		Qua	
18h-19h	138,MATE2, SMA, T, Z02	138,MATE2, SMA, T, Z02	138,MATE2, SMA, T, Z02
19h-20h	138,MATE2, SMA, T, Z02	138,MATE2, SMA, T, Z02	138,MATE2, SMA, T, Z02
20h-21h	147,MTNMT, PUR, TP, F319	147,MTNMT, PUR, TP, F319	147,MTNMT, PUR, TP, F319
21h-22h	147,MTNMT, PUR, TP, F319	147,MTNMT, PUR, TP, F319	147,MTNMT, PUR, TP, F319
22h-23h	142,MECA2, JFJ, T, Z01	142,MECA2, JFJ, T, Z01	142,MECA2, JFJ, T, Z01
23h-24h	142,MECA2, JFJ, T, Z01	142,MECA2, JFJ, T, Z01	142,MECA2, JFJ, T, Z01
		Qui	
18h-19h	146,MTNMT, MDC, T, I301	146,MTNMT, MDC, T, I301	146,MTNMT, MDC, T, I301
19h-20h	146,MTNMT, MDC, T, I301	146,MTNMT, MDC, T, I301	146,MTNMT, MDC, T, I301
20h-21h	148,TERMO, PAA, T, I301	148,TERMO, PAA, T, I301	148,TERMO, PAA, T, I301
21h-22h	148,TERMO, PAA, T, I301	148,TERMO, PAA, T, I301	148,TERMO, PAA, T, I301
22h-23h	137,EMELE, PMA, PL, Z17	137,EMELE, PMA, PL, Z17	137,EMELE, PMA, PL, Z17
23h-24h	137,EMELE, PMA, PL, Z17	137,EMELE, PMA, PL, Z17	137,EMELE, PMA, PL, Z17
		Sex	
18h-19h			
19h-20h			
20h-21h			
21h-22h			
22h-23h			
23h-24h			

LEM_N3	3NA	3NB	3NC
		Seg	
18h-19h	207,PFAB2, AVP, TP, Z05	207,PFAB2, AVP, TP, Z05	213,TRFCA-M, CDA, TP, F202
19h-20h	207,PFAB2, AVP, TP, Z05	207,PFAB2, AVP, TP, Z05	213,TRFCA-M, CDA, TP, F202
20h-21h	211,TRFCA-M, CDA, TP, F317	204,ORMAQ, LAM, TP, F203	
21h-22h	211,TRFCA-M, CDA, TP, F317	204,ORMAQ, LAM, TP, F203	208,PFAB2, AVP, TP, Z10
22h-23h	203,ORMAQ, LAM, TP, F319	212,TRFCA-M, CDA, TP, Z09	208,PFAB2, AVP, TP, Z10
23h-24h	203,ORMAQ, LAM, TP, F319	212,TRFCA-M, CDA, TP, Z09	
		Ter	
18h-19h	201,ORGI1, JAQ, TP, F202	201,ORGI1, JAQ, TP, F202	201,ORGI1, JAQ, TP, F202
19h-20h	201,ORGI1, JAQ, TP, F202	201,ORGI1, JAQ, TP, F202	201,ORGI1, JAQ, TP, F202
20h-21h			205,ORMAQ, LAM, TP, F203
21h-22h			205,ORMAQ, LAM, TP, F203
22h-23h	198,AUTO1, AFS, T, Z04	198,AUTO1, AFS, T, Z04	198,AUTO1, AFS, T, Z04
23h-24h	198,AUTO1, AFS, T, Z04	198,AUTO1, AFS, T, Z04	198,AUTO1, AFS, T, Z04
		Qua	
18h-19h	199,AUTO1, FIL, PL, Z16	199,AUTO1, FIL, PL, Z16	199,AUTO1, FIL, PL, Z16
19h-20h	199,AUTO1, FIL, PL, Z16	199,AUTO1, FIL, PL, Z16	199,AUTO1, FIL, PL, Z16
20h-21h	200,ORGI1, LMF, T, I301	200,ORGI1, LMF, T, I301	200,ORGI1, LMF, T, I301
21h-22h	209,PROJ1, RFS, PL, Z14	209,PROJ1, RFS, PL, Z14	209,PROJ1, RFS, PL, Z14
22h-23h	209,PROJ1, RFS, PL, Z14	209,PROJ1, RFS, PL, Z14	209,PROJ1, RFS, PL, Z14
23h-24h	209,PROJ1, RFS, PL, Z14	209,PROJ1, RFS, PL, Z14	209,PROJ1, RFS, PL, Z14
		Qui	
18h-19h	202,ORMAQ, AJC, T, Z04	202,ORMAQ, AJC, T, Z04	202,ORMAQ, AJC, T, Z04
19h-20h	202,ORMAQ, AJC, T, Z04	202,ORMAQ, AJC, T, Z04	202,ORMAQ, AJC, T, Z04
20h-21h	210,TRFCA-M, FAC, T, Z01	210,TRFCA-M, FAC, T, Z01	210,TRFCA-M, FAC, T, Z01
21h-22h	210,TRFCA-M, FAC, T, Z01	210,TRFCA-M, FAC, T, Z01	210,TRFCA-M, FAC, T, Z01
22h-23h	206,PFAB2, LLM, T, I201	206,PFAB2, LLM, T, I201	206,PFAB2, LLM, T, I201
23h-24h	206,PFAB2, LLM, T, I201	206,PFAB2, LLM, T, I201	206,PFAB2, LLM, T, I201
		Sex	
18h-19h			
19h-20h			
20h-21h			
21h-22h			
22h-23h			
23h-24h			

LEMA_D1	*1DA*	*1DB*	*1DC*	*1DD*	*1DE*
			Seg		
8h-9h	215,ALGEB, ATM, TP, Z05	215,ALGEB, ATM, TP, Z05	229,DEGER, LMT, PL, Z19	221,APROG, ARF, PL, Z16	221,APROG, ARF, PL, Z16
9h-10h	215,ALGEB, ATM, TP, Z05	215,ALGEB, ATM, TP, Z05	229,DEGER, LMT, PL, Z19	221,APROG, ARF, PL, Z16	221,APROG, ARF, PL, Z16
10h-11h			229,DEGER, LMT, PL, Z19	238,IEAUT, APM, PL, F322	
11h-12h	235,IEAUT, JJV, PL, F226	219,APROG, ARF, PL, F216	229,DEGER, LMT, PL, Z19	238,IEAUT, APM, PL, F322	239,IEAUT, RRM, PL, Z15
12h-13h	235,IEAUT, JJV, PL, F226	219,APROG, ARF, PL, F216			239,IEAUT, RRM, PL, Z15
			Ter		
8h-9h	218,APROG, ARF, PL, Z16	224,CMATE, FAF, PL, Z15	237,IEAUT, RRM, PL, F214	230,DEGER, HMG, PL, Z18	230,DEGER, HMG, PL, Z18
9h-10h	218,APROG, ARF, PL, Z16	224,CMATE, FAF, PL, Z15	237,IEAUT, RRM, PL, F214	230,DEGER, HMG, PL, Z18	230,DEGER, HMG, PL, Z18
10h-11h			220,APROG, ARF, PL, F218	230,DEGER, HMG, PL, Z18	230,DEGER, HMG, PL, Z18
11h-12h			220,APROG, ARF, PL, F218	230,DEGER, HMG, PL, Z18	230,DEGER, HMG, PL, Z18
12h-13h	217,APROG, ARF, T, F342	217,APROG, ARF, T, F342	217,APROG, ARF, T, F342	217,APROG, ARF, T, F342	217,APROG, ARF, T, F342
			Qua		
8h-9h	223,CMATE, FAF, PL, F225	236,IEAUT, RRM, PL, F322	233,FISIC, PAF, TP, Z10	233,FISIC, PAF, TP, Z10	233,FISIC, PAF, TP, Z10
9h-10h	223,CMATE, FAF, PL, F225	236,IEAUT, RRM, PL, F322	233,FISIC, PAF, TP, Z10	233,FISIC, PAF, TP, Z10	233,FISIC, PAF, TP, Z10
10h-11h	231,FISIC, PAF, T, Z03	231,FISIC, PAF, T, Z03	231,FISIC, PAF, T, Z03	231,FISIC, PAF, T, Z03	231,FISIC, PAF, T, Z03
11h-12h	232,FISIC, PAF, TP, Z09	232,FISIC, PAF, TP, Z09	216,ALGEB, ATM, TP, Z07	216,ALGEB, ATM, TP, Z07	216,ALGEB, ATM, TP, Z07
12h-13h	232,FISIC, PAF, TP, Z09	232,FISIC, PAF, TP, Z09	216,ALGEB, ATM, TP, Z07	216,ALGEB, ATM, TP, Z07	216,ALGEB, ATM, TP, Z07
			Qui		
8h-9h	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02
9h-10h	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02	214,ALGEB, ATM, T, Z02
10h-11h	222,CMATE, RBC, T, Z03	222,CMATE, RBC, T, Z03	222,CMATE, RBC, T, Z03	222,CMATE, RBC, T, Z03	222,CMATE, RBC, T, Z03
11h-12h	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04
12h-13h	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04	234,IEAUT, APM, T, Z04
			Sex		
8h-9h	227,DEGER, LMT, PL, F218	228,DEGER, HMG, PL, Z13	225,CMATE, FAF, PL, F221		
9h-10h	227,DEGER, LMT, PL, F218	228,DEGER, HMG, PL, Z13	225,CMATE, FAF, PL, F221		
10h-11h	227,DEGER, LMT, PL, F218	228,DEGER, HMG, PL, Z13			
11h-12h	227,DEGER, LMT, PL, F218	228,DEGER, HMG, PL, Z13		226,CMATE, FAF, PL, F214	226,CMATE, FAF, PL, F214
12h-13h				226,CMATE, FAF, PL, F214	226,CMATE, FAF, PL, F214

LEMA_D2	*2DA*	*2DB*	*2DC*
		Seg	
13h-14h	245,MATE2, DC3, TP, F208	249,MECA2, HML, TP, F209	243,ELETRO, RMB, PL, Z13
14h-15h	245,MATE2, DC3, TP, F208	249,MECA2, HML, TP, F209	243,ELETRO, RMB, PL, Z13
15h-16h	258,TERMO, PAA, TP, Z05	249,MECA2, HML, TP, F209	250,MECA2, REM, TP, Z08
16h-17h	258,TERMO, PAA, TP, Z05	242,ELETRO, RMB, PL, F221	250,MECA2, REM, TP, Z08
17h-18h		242,ELETRO, RMB, PL, F221	250,MECA2, REM, TP, Z08
		Ter	
13h-14h	255,MTNMT, NAL, TP, Z06	253,MECV1, ADP, TP, F203	253,MECV1, ADP, TP, F203
14h-15h	255,MTNMT, NAL, TP, Z06	253,MECV1, ADP, TP, F203	253,MECV1, ADP, TP, F203
15h-16h	248,MECA2, HML, TP, Z11	246,MATE2, DC3, TP, F202	246,MATE2, DC3, TP, F202
16h-17h	248,MECA2, HML, TP, Z11	246,MATE2, DC3, TP, F202	246,MATE2, DC3, TP, F202
17h-18h	248,MECA2, HML, TP, Z11		
		Qua	
13h-14h	241,ELETRO, RMB, PL, F224	259,TERMO, RFR, TP, Z06	259,TERMO, RFR, TP, Z06
14h-15h	241,ELETRO, RMB, PL, F224	259,TERMO, RFR, TP, Z06	259,TERMO, RFR, TP, Z06
15h-16h	247,MECA2, HML, T, Z01	247,MECA2, HML, T, Z01	247,MECA2, HML, T, Z01
16h-17h	247,MECA2, HML, T, Z01	247,MECA2, HML, T, Z01	247,MECA2, HML, T, Z01
17h-18h	257,TERMO, PAA, T, F341	257,TERMO, PAA, T, F341	257,TERMO, PAA, T, F341
		Qui	
13h-14h	240,ELETRO, RMB, T, Z03	240,ELETRO, RMB, T, Z03	240,ELETRO, RMB, T, Z03
14h-15h	252,MECV1, APM, TP, F207	256,MTNMT, NAL, TP, Z09	256,MTNMT, NAL, TP, Z09
15h-16h	252,MECV1, APM, TP, F207	256,MTNMT, NAL, TP, Z09	256,MTNMT, NAL, TP, Z09
16h-17h	254,MTNMT, MDC, T, F342	254,MTNMT, MDC, T, F342	254,MTNMT, MDC, T, F342
17h-18h	251,MECV1, APM, T, F342	251,MECV1, APM, T, F342	251,MECV1, APM, T, F342
		Sex	
13h-14h	244,MATE2, MJO, T, I301	244,MATE2, MJO, T, I301	244,MATE2, MJO, T, I301
14h-15h			
15h-16h			
16h-17h			
17h-18h			

LEMA_D3	*3DA*	*3DB*	*3DC*	*3DD*
		Seg		
8h-9h	266,CALCL1, JMS, TP, F202	286,PRIN1, MRP, T, I201	276,ELTRA, NDG, PL, Z18	272,DACOM, JPR, PL, Z13
9h-10h	266,CALCL1, JMS, TP, F202	275,ELTRA, JAA, PL, F221	276,ELTRA, NDG, PL, Z18	272,DACOM, JPR, PL, Z13
10h-11h	285,PRIN1, MRP, T, I201	275,ELTRA, JAA, PL, F221		272,DACOM, JPR, PL, Z13
11h-12h	283,IEGIN, VEC, TP, F209	283,IEGIN, VEC, TP, F209	268,CALCL1, JMS, TP, F203	268,CALCL1, JMS, TP, F203
12h-13h	283,IEGIN, VEC, TP, F209	283,IEGIN, VEC, TP, F209	268,CALCL1, JMS, TP, F203	268,CALCL1, JMS, TP, F203
		Ter		
8h-9h	262,ALGOR, ACT, PL, Z12	267,CALCL1, JMS, TP, Z10		288,PRIN1, MRP, T, I301
9h-10h	262,ALGOR, ACT, PL, Z12	267,CALCL1, JMS, TP, Z10	287,PRIN1, MRP, T, F341	277,ELTRA, JAA, PL, Z13
10h-11h	262,ALGOR, ACT, PL, Z12	280,FIGER, JNP, PL, Z19		277,ELTRA, JAA, PL, Z13
11h-12h	274,ELTRA, NDG, PL, Z15	280,FIGER, JNP, PL, Z19	284,IEGIN, VEC, TP, F209	284,IEGIN, VEC, TP, F209
12h-13h	274,ELTRA, NDG, PL, Z15	280,FIGER, JNP, PL, Z19	284,IEGIN, VEC, TP, F209	284,IEGIN, VEC, TP, F209
		Qua		
8h-9h	265,CALCL1, JMS, T, Z02	265,CALCL1, JMS, T, Z02	265,CALCL1, JMS, T, Z02	265,CALCL1, JMS, T, Z02
9h-10h	265,CALCL1, JMS, T, Z02	265,CALCL1, JMS, T, Z02	265,CALCL1, JMS, T, Z02	265,CALCL1, JMS, T, Z02
10h-11h	279,FIGER, JNP, PL, Z17	263,ALGOR, ACT, PL, F224	271,DACOM, MON, PL, F221	
11h-12h	279,FIGER, JNP, PL, Z17	263,ALGOR, ACT, PL, F224	271,DACOM, MON, PL, F221	
12h-13h	279,FIGER, JNP, PL, Z17	263,ALGOR, ACT, PL, F224	271,DACOM, MON, PL, F221	
		Qui		
8h-9h	269,DACOM, JPR, PL, Z12	270,DACOM, MON, PL, Z18	264,ALGOR, ACT, PL, Z14	264,ALGOR, ACT, PL, Z14
9h-10h	269,DACOM, JPR, PL, Z12	270,DACOM, MON, PL, Z18	264,ALGOR, ACT, PL, Z14	264,ALGOR, ACT, PL, Z14
10h-11h	269,DACOM, JPR, PL, Z12	270,DACOM, MON, PL, Z18	264,ALGOR, ACT, PL, Z14	264,ALGOR, ACT, PL, Z14
11h-12h	273,ELTRA, NDG, TP, F202	273,ELTRA, NDG, TP, F202	273,ELTRA, NDG, TP, F202	273,ELTRA, NDG, TP, F202
12h-13h	278,FIGER, JNP, T, I301	278,FIGER, JNP, T, I301	278,FIGER, JNP, T, I301	278,FIGER, JNP, T, I301
		Sex		
8h-9h	260,ALGOR, ACT, TP, F204	260,ALGOR, ACT, TP, F204	281,FIGER, JNP, PL, Z14	281,FIGER, JNP, PL, Z14
9h-10h			281,FIGER, JNP, PL, Z14	281,FIGER, JNP, PL, Z14
10h-11h			281,FIGER, JNP, PL, Z14	281,FIGER, JNP, PL, Z14
11h-12h	282,IEGIN, VEC, T, I301	282,IEGIN, VEC, T, I301	282,IEGIN, VEC, T, I301	282,IEGIN, VEC, T, I301
12h-13h			261,ALGOR, ACT, TP, Z10	261,ALGOR, ACT, TP, Z10

DECLARAÇÃO DE INTEGRIDADE

DECLARAÇÃO DE INTEGRIDADE

Declaro ter conduzido este trabalho académico com integridade. Não plagiei ou apliquei qualquer forma de uso indevido de informações ou falsificação de resultados ao longo do processo que levou à sua elaboração.

Declaro que o trabalho apresentado neste documento é original e de minha autoria, não tendo sido utilizado anteriormente para nenhum outro fim.

Declaro ainda que tenho pleno conhecimento do Código de Conduta Ética do P.PORTO.

Isa Fernandes

ISEP, Porto, 20 de setembro de 2024