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SCHEDULING COURSES IN A UNIVERSITY

BY

SHAIK KHASIMUL AZMATH

A Thesis Presented to the
DEANSHIP OF GRADUATE STUDIES

KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

DHAHRAN, SAUDI ARABIA

In Partial Fulfillment of the
Requirements for the Degree of

MASTER OF SCIENCE

In

SYSTEMS ENGINEERING

June, 2002

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KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS

DHAHRAN, SAUDI ARABIA

COLLEGE OF GRADUATE STUDIES

This thesis, written by

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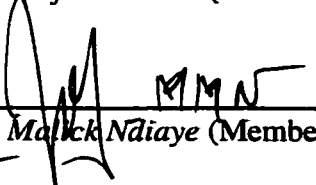
under the direction of his Thesis Advisor and approved by his Thesis Committee, has

been presented to and accepted by the Dean of the College of Graduate Studies, in partial

fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS ENGINEERING

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Date: _03 - 7 - 2002_

Dedicated to

My beloved parents and brothers

Whose prayers, sacrifice, inspiration and love

Led to this accomplishment

Acknowledgement

In the name of Allah, Most Gracious, Most Merciful. Read in the name of

thy Lord and Cherisher, Who created. Created man from a { leech-like }

clot. Read and thy Lord is Most Bountiful. He Who taught { the use of }

the pen. Taught man that which he knew not. Nay, but man doth transgress

all bounds. In that he looketh upon himself as self-sufficient. Verily, to thy

Lord is the return { of all }.

(*The Holy Quran, Surah 96*)

I also wish to thank the faculty and the staff members of the Systems Engineering Department for their support.

Special acknowledgements are due to my long lasting friend Gulam Ali Akber and to all my other friends at KFUPM for their moral support, good wishes and the memorable days we shared together.

Finally, I thank my parents and brothers and bhabhi for their love, sacrifices, prayers and understanding. They helped me a lot in achieving my objectives.

Contents

List of Figures

Abstract

Name: Shaik Khasimul Azmath

Title: Scheduling Courses in a University

Degree: Master of Science

Major Field: Systems Engineering

Date of Degree: June 2002

Most modeling approaches in institutions of higher learning tend to be directed towards planning of human, financial, and physical resources in the higher levels of academic administration planning. However, these models cannot easily be applied at the departmental level. At the department level, problems such as course-faculty-time scheduling exist, and need special modeling approaches. Method of grouping as aid in course-time assignment has been a recent trend. In the current work the grouping of departments w.r.t. their locations is studied and a model is developed for the departments of KFUPM. The study further mentions the different strategies of constraint development using grouping.

King Fahd University of Petroleum and Minerals, Dhahran.

June 2002

ملخص الرسالة

الاسم:	شيخ قاسم الا زمث
عنوان الرسالة:	جدولة الدروس فى جامعة
التخصص:	ماجستير علوم
تاريخ التخرج:	يونيو, م2002

معظم طرق النمادج فى معاهد الدراسات العليا تميل الى ان تكون موجهه الى ناحية تخطيط الموارد البشرية والماليه والمادية فى المستويات العليا لتخطيط الادارة الاكاديمية. ولكن هذة النمادج لايمكن تطبيقها بسهولة على مستوى الاقسام. على مستوى الاقسام مشكلات مثل جدولة الدرس-المدرس- الوقت موجودة وتحتاج الى نمادج خاصة. طرق التجميع كمساعدة فى تحديد الدرس-الوقت يعتبر منحى جديد. فى هذا العمل يتم دراسة تجميع الاقسام من ناحية مواقعها وتم تطوير نمودج لاقسام جامعة الملك فهد للبترول والمعادن. الدراسة تذكر الاستراتيجيات المختلفة لتطوير الشروط المحددة باستخدام التجميع.

درجة الماجستير فى العلوم

جامعة الملك فهد للبترول والمعادن

الظهران, المملكة العربية السعودية

يونيو, 2002 م

Chapter 1

Introduction

A timetable is a placement of a set of meetings in time. A meeting is a combination of resources (e.g. rooms, people and items of equipment), some of which may be specified by time problem, and some of which must be allocated as part of the solution. Timetabling has long been known to belong to the class of problems called NP-complete, i.e. no method of solving it in a reasonable (polynomial) amount of time is known.

Different sub domains can be distinguished within the class of academic timetabling problems. More related to teaching are the following three sub domains: assigning rooms and times to each section of a course, assigning teachers to courses, and grouping. Theoretically all of these sub-problems should be solved simultaneously to obtain an optimal timetable. However, since solving each problem by itself is complex, devising an integrated solution of the overall problem is almost impossible.

1.1 Types of Timetabling Problems

There are several fundamental variations of the timetabling problem. University timetabling can be divided into two main categories: lectures and examinations. The major differences between lecture scheduling and exam scheduling are:

1. Exams must be scheduled so that no student has more than one exam at a time, but lectures must usually be scheduled before student enrolments are known.

2. As space is often a constraint, exams often share rooms, or are split across rooms, but only one lecture may be held in a room at any time.

1.2 Proposed Work

We propose a model of scheduling of courses in our university considering various rules both at the University level and also at the departmental level regarding the courses and classroom assignment. We propose different strategies of generating the constraints for the problem considered in thesis. A highly powerful optimization tool is to be used for solving the generated set of constraints for the scheduling problem.

1.3 Organization of the Thesis

In Chapter 2, the literature survey related to this thesis is presented along with the basic concepts of Timetabling and its various forms and its development. In Chapter 3 we describe formulation of the problem. The data used for the work was provided by the Registrar Office of King Fahd University of Petroleum and Minerals, analyzed and described in Chapter 4. The method of generation of the constraints using the data is presented in the Chapter 5 of the Thesis. Finally in Chapter 6 the results of the thesis are discussed and recommendations for future work are mentioned.

Chapter 2

Literature Review

The approaches for solution of the timetabling problem have been from pure simulation of hand construction of a timetable (Barraclough [51], Murphy and Sutter [53]) to graph theoretic approaches (Welsh and Powell [54] and Wood [49]). The programs developed by Purdue University in 1956 and CLASS (Class Load And Student Scheduling) developed by IBM shortly thereafter fall in the category of simulation of hand construction of a timetable. Most of the previous studies have dealt with school timetabling problems (Aust [45], Barraclough [51], Csima and Gotlieb [52], DeWerra [37,44], Lawrie [48], Murphy and Sutter [53] and others). There are relatively few studies dealing with the College or University timetabling problems (Akkoyunlu [46] Almond [55]) and some with examination timetabling problem (Laporte and Desroches 1982 [34], Wood [49]). A survey of these examination timetabling problem done by Carter [35], in that comparatively less amount of work done on college/university timetabling is largely due to the opinion that it is easier to construct a college timetable than a school timetable, as the conflicts are likely to be less in a college situation.

This generalization does hold good in some cases but certainly not in case of undergraduate school timetabling considered here. The present study can be extended to other university/college situations and to other similar problems. One of the characteristics of the timetabling problem is its large size. This becomes a great hindrance to solving the timetabling problem using mathematical programming techniques. In a mathematical programming formulation of the timetabling problem all the variables are integers, which is a further deterrent for using such a technique. The use of relaxation techniques based on Lagrangean multipliers to solve the Integer Linear Programming problem has shown great promise since the beginning of the 1970's. [38]

Recently heuristic search techniques like Tabu search (Daniel Costa, 1994 [18]), Neural Networks (Matevz Kovacic [20]) and Genetic Algorithms (Angelo Monfroglio, [14]) have also been applied. Although they present a solution for the Timetabling problem, they are too complex to apply on realistic situations.

2.1 The Timetabling Problem

The problem considered here deals with scheduling of about 545 course sections over an academic semester in an undergraduate program. There is an increased complexity due to the fact that students from different levels have to study a particular subject. When such a subject is scheduled in a period, all the other subjects which are also to be studied by the students from these different levels cannot be scheduled in the same period. Such situations are quite common in the timetabling problem considered here. The academic year is divided into two semesters. The timetable is made separately for all the 2 semesters. The semester timetable has to deal with about 400 to 450 subjects. If the week is of 30 periods, a direct mathematical programming formulation results in

over 12000 variables and nearly as many constraints. All the variables are integer valued. The size of the integer linear programming problem so formulated becomes unmanageable to handle. In order to reduce the size of the problem the variables need to be redefined, and this is achieved through a 'grouping' operation. Grouping is discussed in Chapter 3

2.1.1 The Traditional Timetabling Problem

In a review article, DeWerra [37,44] noted that there are two distinct stages to the timetabling process, namely,

1. First, the curricula are defined for each class or for each group of students, and the necessary teaching resources (staff, equipment and space) are assigned.

2. Second, when an agreement has been reached concerning these assignments of resources, then one tries to see whether a workable detailed timetable can be worked out which is compatible with all the previously defined requirements'.

Although some work has been done on the assignment problems implicit in the first stage, the traditional timetabling problem is usually identified with the second stage, that of ordering the various classes or groups over a specified period of time (usually a week) subject to stated restrictions on the various resources involved. Indeed most of the approaches described in the Operations Research and computing literature relate to some aspect of this second stage, usually in the context of a specific problem situation.

At its most basic, stage 2 of the timetabling problem involves a number of sets of students (groups) who each follow a pre-defined program of meetings (classes) with a specified set of teachers. These program can be specified as a requirements matrix $C = (C_{ij})$ where C_{ij} is the number of classes given by teacher j to group i. If we assume that all

classes have the same duration (a period), then the problem is to assign each class to some period within the timetable (e.g. during a week) such that no group and no teacher is involved in more than one class in any period.

The problem can easily be stated in algebraic terms if we define a set of binary variables x_{ijk} where $x_{ijk} = 1$ if group i meets teacher j in period k, and $x_{ijk} = 0$ otherwise.

As it stands, this is a feasibility (or satisficing) problem rather than an optimality problem. The aim is to find a feasible or satisfactory resolution of the stated constraints rather than to optimize a chosen objective function. This is because, in most timetabling situations, there is no overriding objective which must be optimized to the exclusion of all else. Rather there are a number of possible goals, which are usually seen as desirable ends rather than critically important objectives or absolute constraints. For example, it is usually seen as desirable to even out the workload of the teachers so that they do not have all of their free periods in one day. Likewise, it may be preferable to minimize the number of classes offered early or late in the day.

2.1.2 General Timetabling Constraints

The timetabling problem consists of assigning each lecture of each course to a period while taking the following constraints into account: [3]

1. *Teacher overlaps*: a teacher cannot be involved simultaneously in more than one lecture.

2. *Class overlaps*: a class cannot be involved simultaneously in more than one lecture.

3. *Room overlaps*: at every period and for each type of special room, the number of rooms required cannot be larger than the number of available rooms.

4. *Preassignment constraints*: certain lectures are preassigned to a set of specific periods and therefore have to be scheduled during these given periods.

laboratory) just before a lecture requiring a particular preparation. These requirements concern only special rooms since the number of ordinary rooms is supposed to be unlimited.

14. *Variable lunch break*: when a lunch break must be planned daily during one among two consecutive periods (called first and second break period), teachers and classes cannot attend more than one single lecture during the two considered periods.

15. *Balanced lunch break*: during each variable lunch break the number of classes having the break at the first break period should not be very different from the number of classes having the break at the following period. This requirement must be taken into account in institutions where the dining hall is not large enough to contain all the students at a same time.

2.2 The Realistic Situation

Even the simplest educational timetable will involve a number of additional constraints beyond those mentioned. What follows is by no means an exhaustive list of such constraints, but it will at least serve to illustrate some of the difficulties that can be expected to arise in practice.

Not all classes last the same amount of time. In many situations, all classes are some multiple of the basic period, but in some cases, classes of a totally different time might have to be incorporated.

No account is taken in the basic model of teaching space. Realistically, we can usually assume that there are enough teaching rooms available in total to accommodate all groups of students, but there will inevitably be problems caused by the use of specialist rooms such as laboratories or workshops. These problems become particularly

'book-keeping' function that is required to maintain the lists and tables that are a necessary part of almost any realistic timetabling system.

As regards the first requirement, the computation involved can be very extensive and time consuming, and so tends to be concentrated on mainframe computers. Many of the more successful applications therefore, seem to be in the university or college environment, or in school situations, which are more, centrally planned and coordinated.

2.4 Major Papers related to the Proposed Thesis

The basis of generating constraints in the proposed thesis are the two papers, Badri et al [3,11] and Schniederjans [31], which have been thoroughly studied and their results were verified.

2.4.1 Badri et al: [3,11]

The model in this paper seek to overcome limitations of the Harwood and Lawless model, to deal with the course-time assignment problem that was not included in the Schniederjans and Kim [31] model, and also to perform the analysis in one stage rather than two, as in the Badri [3] model.

2.4.2 Schniederjans and Kim [31]

The purpose of this paper was to present an application of goal programming in course-faculty teaching assignments. The model examines the conflicting objectives of departmental course and teaching load goals with those of faculty course preferences. The model was applied in a real-world setting and implementation results were discussed.

The models of these papers were solved using LINGO software package as a part of literature survey.

Chapter 3

Problem Formulation

3.1   Problem Description

A mathematical formulation of the problem is now introduced. The problem includes two main components, the timetabling subproblem and the grouping subproblem. First, several concepts have to be specified to characterize the problem.

Each student registers in a set of courses, large courses in which numerous students are expected to be registered are split into several sections of a course which are offered at different times or different rooms and are considered as separate courses. Hence groups of students registered in such a course are determined

3.2   Assumptions

The assumptions considered during the research work are the following

1. No faculty is in two or more different sections at the same time-period.

2. Each section is assigned a specific faculty member

3. Courses are for one semester only and only undergraduate courses are considered.

4. Only allocation of classrooms is considered as the laboratories are taught in rooms belonging to respective the department.

5. In order to construct a mathematical program of manageable size we grouped the courses offered at KFUPM into four groups. Grouping of different departments is done according to the availability of classrooms in the buildings in and near the departments. These groups are shown in Table 3.1

Table 3.1: Departmental Grouping

GROUP	DEPARTMENT	BUILDINGS USED BY THESE DEPARTMENTS
I	Accounting & Management Information Systems Computer Engineering Earth Sciences Finance & Economics Information & Computer Science Management & Marketing Mechanical and Aerospace Engineering Systems Engineering	22 and 24
II	Chemical Engineering Chemistry Civil Engineering Mathematical Sciences Petroleum Engineering	3, 4 and 5
III	Architectural Engineering Architecture City and Regional Planning Construction Engineering Management	19

IV	Electrical Engineering Islamic and Arabic Studies Physics	6, 7 and 14

3.3 The Timetabling Problem

The problem considered in this thesis deals with scheduling of one of the above groups, namely, Group I consisting of 545 sections, in an undergraduate program of one academic semester. The students enrolled in seven different departments in the undergraduate program. In the design of the Time-Table one should take into consideration that students take a set of courses and time conflicts among these courses are not allowed. Such situations are quite common in the timetabling problem considered here. The timetable has to deal with 545 sections.

Each section is taught in a specified number of lectures each week. The length of these lectures vary; some may last 50 minutes, some 75 minutes, etc. In the timetabling problem starting times have to be assigned to lectures.

The concept of a conflict between lectures must be considered. Since the length of lectures is not uniform, it follows that two lectures with different starting times can overlap.

3.4 Problem Development

3.4.1 Period Classification

A course has at least one section. A section could be one of the following cases

Table 3.2: Period Classification

Three times a week, 50 minutes each meeting (S1)

001	S, M, W	07.00	08.00
002	S, M, W	08.00	09.00
003	S, M, W	09.00	10.00
004	S, M, W	10.00	11.00
005	S, M, W	11.00	12.00
006	S, M, W	01.00	02.00
007	S, M, W	02.00	03.00
008	S, M, W	03.00	04.00

Two times a week, 50 minutes each meeting (S2)

009	UT	07.00	08.00		017	SM	07.00	08.00
010	UT	08.00	09.00		018	SM	08.00	09.00
011	UT	09.00	10.00		019	SM	09.00	10.00
012	UT	10.00	11.00		020	SM	10.00	11.00
013	UT	11.00	12.00		021	SM	11.00	12.00
014	UT	01.00	02.00		022	SM	01.00	02.00
015	UT	02.00	03.00		023	SM	02.00	03.00
016	UT	03.00	04.00		024	SM	03.00	04.00

Two times a week, 75 min each meeting (S3)

025	UT	07.00	08.15		037	SM	07.00	08.15
026	UT	08.00	09.15		038	SM	08.00	09.15
027	UT	09.00	10.15		039	SM	09.00	10.15
028	UT	10.00	11.15		040	SM	10.00	11.15
029	UT	11.00	12.15		041	SM	11.00	12.15
030	UT	01.00	02.15		042	SM	01.00	02.15
031	UT	02.00	03.15		043	SM	02.00	03.15
032	UT	03.00	04.15		044	SM	03.00	04.15
033	UT	07.30	08.45		045	SM	07.30	08.45
034	UT	08.30	09.45		046	SM	08.30	09.45
035	UT	09.30	10.45		047	SM	09.30	10.45
036	UT	10.30	11.45		048	SM	10.30	11.45

Labs: 3 consecutive hrs (S4)

049	S	07.00	10.00		059	M	07.00	10.00
050	S	08.00	11.00		060	M	08.00	11.00
051	S	09.00	12.00		061	M	09.00	12.00

052	S	01.00	04.00
053	S	02.00	05.00
054	U	07.00	10.00
055	U	08.00	11.00
056	U	09.00	12.00
057	U	01.00	04.00
058	U	02.00	05.00

062	M	01.00	04.00
063	M	02.00	05.00
064	T	07.00	10.00
065	T	08.00	11.00
066	T	09.00	12.00
067	T	01.00	04.00
068	T	02.00	05.00

3.4.2 Determination of Overlapping Periods

Since the duration of lectures is not uniform, it follows that two lectures with different starting times can overlap. For example period 001 overlaps with period 045. The set of overlapping periods was devised by a simple technique.

First the whole day was divided into quarter hours from 7 A.M. to 5 P.M. as shown in the Table 3.3. The numbers at the top of the table denote column number. The number between the next two bold lines denote the quarter of each hour from 7 A.M. to 5 P.M. So, for example the sequence 10 10 10 10 refer to the quarter hours starting at 10:00 A.M. 10:15 A.M. 10:30 A.M. and 10:45 A.M. respectively. For each column we write the periods which include this quarter hour. For example column 20 include all the time periods on Saturday, Monday and Wednesday, which run at the same time. Thus on Saturday the periods 5, 21, 41 and 51 overlap, on Monday 5, 21, 41 and 61 overlap and on Wednesday there are no overlapping because we have only set of Wednesday periods, i.e., S1 periods. Note that columns 22, 23, 24 and 25 are identical. So only one column can represent these four. This observation is noticed in other locations. A similar strategy is applied for UT Sections shown in Table 3.4. Table 3.5 is obtained from Table 3.3 and Table 3.4 after eliminating repeated columns.

We have a final set of overlapping periods, which total to 44 and are shown in Table 3.6

Table 3.3: Raw form for determining the overlapping periods (Saturday, Monday, Wednesday)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
	7	7	7	7	8	8	8	8	2	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	7	7	7	7	8	8	8	8	8	4	4	4	4
S	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6	7	7	7	7	7	8	8	44	53	53	53
S	17	17	17	18	18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24	24	24	53												
S	37	37	37	38	38	38	39	39	39	40	40	40	41	41	41	42	42	42	43	43	43	44	44	44													
S	49	45	45	45	46	46	46	47	47	47	48	48	48	40	41	42	43	52	52	52	52	52	52														
S	49	49	49	46	46	47	47	50	50	50	48	48	50	51	52	53	52	53	53	53																	
S		50	50	50	49	49	50	50	51	51	51	53																									
S				50	50	51	51	51																													
S						51																															
M	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6	7	7	7	7	7	8	8	44	63	63	63
M	17	17	17	18	18	18	19	19	19	20	20	20	21	21	21	22	22	22	23	23	23	24	24	24	63												
M	37	37	37	38	38	38	39	39	39	40	40	40	41	41	41	42	42	42	43	43	43	44	44	44													
M	59	59	59	46	46	46	38	40	40	40	48	48	40	41	42	43	62	62	62	62	62	62															
M	59	60	59	46	46	59	59	60	60	60	48	48	60	61	62	63	62	63	63	63																	
M		60	60	60	59	59	60	60	61	61	61	61	43	63	63	63																					
M				60	60	61	61	61																					62								
M						61																								62							
M																															63						
W	1	1	1	2	2	2	2	3	3	3	3	3	4	4	4	4	4	5	5	5	5	5	6	6	6	6	7	7	7	7	7	8	8	8	8	8	8

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Table 3.4: Raw form for determining the overlapping periods (Sunday, Tuesday)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
	7	7	7	8	8	8	9	9	9	10	10	10	11	11	11	12	12	12	1	1	1	2	2	2	2	3	3	3	3	4	4	4	4	4	4	4	4
U	9	9	9	10	10	10	11	11	11	11	12	12	12	13	13	13	13	13	29	14	14	14	14	15	15	15	15	15	16	16	16	16	32	58	58		
U	25	25	25	26	26	26	27	27	27	28	28	28	28	29	29	29	30	30	30	30	31	31	31	31	31	57	57	57	57	32	32	58					
U	54	54	33	33	33	33	34	34	35	35	36	36	35	35	36	29	29	36	56	57	57	57	32	57	57	57											
U	54	54	34	34	35	35	34	34	54	54	55	55	55	36	36	56	56	58	57	58	58	58															
U	54	55	55	55	54	54	55	55	56	56	55	55	56	58																							
U	55	55	55	56	56	56	56																														
U		56	56	56																																	
T	9	9	9	10	10	10	11	11	11	11	12	12	12	13	13	13	13	13	29	14	14	14	14	15	15	15	15	16	16	16	16	32	68	68	68		
T	25	25	25	26	26	26	27	27	27	28	28	28	28	29	29	29	30	30	30	30	31	31	31	31	31	67	67	67	67	32	32	68					
T	64	64	33	33	33	33	34	34	35	35	36	36	35	35	36	28	28	36	66	67	67	67	32	67	67	67											
T	64	64	64	34	34	34	64	64	64	64	34	35	35	36	36	65	67	66	67	68	68	68															
T		65	65	64	64	65	64	65	65	65	65	66	66	66																							
T			65	65	66	66	66	66	68																												

Table 3.6: Final overlapping period sets

	S1	S2	S3	S3	S3	S4	S4	S4
01	001	017	037	045		049		
02	002	018	037	038	045	049	050	
03	002	018	038	045	046	049	050	
04	003	019	038	039	046	049	050	051
05	003	019	039	046	047	049	050	051
06	004	020	039	040	047	050	051	
07	004	020	040	047	048	050	051	
08	005	021	040	041	048	051		
09	006	022	042			052		
10	007	023	042	043		052	053	
11	008	024	043	044		052	053	
12	001	017	037	045		059		
13	002	018	038	037	045	059	060	
14	002	018	038	045	046	059	060	
15	003	019	038	039	046	059	060	061
16	003	019	039	046	047	059	060	061
17	004	020	039	040	047	060	061	
18	004	020	040	047	048	060	061	
19	005	021	040	041	048	061		
20	006	022	042			062		
21	007	023	042	043		062	063	
22	008	024	043	044		062	063	
23		009	025	033		054		
24		010	025	026	033	054	055	
25		010	026	033	034	054	055	
26		011	026	027	034	054	055	056
27		011	027	034	035	054	055	056
28		012	027	028	035	055	056	
29		012	028	035	036	055	056	
30		013	028	029	036	056		
31		014	030			057		
32		015	030	031		057	058	
33		016	031	032		057	058	
34		009	025	033		064		
35		010	025	026	033	064	065	
36		010	026	033	034	064	065	
37		011	026	027	034	064	065	066
38		011	027	034	035	064	065	066
39		012	027	028	035	065	066	
40		012	028	035	036	065	066	
41		013	028	029	036	066		
42		014	030			067		
43		015	030	031		067	068	
44		016	031	032		067	068	

Now as the Sunday-Tuesday (UT) classes do not overlap with Saturday-Monday-Wednesday (SMW) of other set of time-periods they were considered separately. The first set of SMW, SM time periods were considered and were placed accordingly in the

3.5.2 Faculty Constraints:

A faculty member teaches at most one section at any time period. Let M denote the number of faculty member, N is the number of overlapping periods set Let F_m be the set of sections faculty member m is teaching. Let C_n be the nth overlapping period set. In the example being studied in this work M = 228 and N = 44. The constraints are given by

$$\sum_{i \in F_m} \sum_{j \in C_n} X_{ij} \leq 1 \qquad m = 1, M \quad and \quad n = 1, N$$

A sample of this type of constraints is shown in Chapter 5

3.5.3 Classroom Constraints

We consider only the assignment of classrooms to lectures. Lab sections are assumed to be offered in special rooms belonging to the department as mentioned in the assumptions. The classes available are grouped according to the capacity and the sections are grouped according to the maximum enrollment capacity of the course. The capacity of the rooms and the enrollment capacity of the courses are grouped into two sets.

Set R_1 contains the section with maximum enrollment capacity ≤ 30

Set R_2 contains the sections with enrollment capacity > 30

r_1 is the number of classrooms with capacity ≤ 30 (Small Classrooms)

r_2 is the number of classrooms with capacity > 30 (Large Classrooms)

and thus the respective groups of number of classrooms available and courses to be assigned are combined to get the constraints. A sample of this type of constraints is shown in Chapter 5.

$$\sum_{i \in R_1} \sum_{j \in S} X_{ij} = r_1$$

$$\sum_{i \in R_2} \sum_{j \in S} X_{ij} = r_2$$

where S takes the values in the sets S_1, S_2, S_3 or S_4

3.5.4 Section Cluster Constraints

Some courses should not run in the same time because a group of students may need to take all of them. Sections of same level and two consecutive levels have to be offered at different times to ensure choices of the faculty and time for the students. For example Junior students may take SE 302, SE 303 and SE 320 in the same semester. If there is one section of each course, then these courses should not be offered at overlapping time periods. On the other hand if there are multiple sections of some of these courses then we divide the sections into two clusters. Sections in the same cluster should not overlap and the other may overlap. For example Table 3.7 below show courses, the corresponding sections and the groups.

Table 3.7: Illustration of Section Clustering

Course	Sections	Group I		Group II	
SE 302	1, 2, 3, 4	1	2	3	4
SE 303	1,2	1		2	
SE 320	1, 2, 3	1	2	3	

In this example sections SE 302-1, SE 303-1 and SE 320-1 should not be at the same time period. The courses in each department were studied and the clusters were constructed according to the rules of the department. Chapter 5 shows some of these constraints.

Chapter 4

Analysis of the Data

The data for the model was obtained from the Deanship of Admissions and Registration, KFUPM. The data was analyzed for generating various constraints. Various tables were created for the generation of the constraints as described below

- Systems Engineering (Tables 4.1, 4.9, 4.18)

- Computer Engineering (Tables 4.2, 4.10, 4.19)

- Information & Computer Science (Tables 4.3, 4.11, 4.20)

- Mechanical Engineering (Tables 4.4, 4.12, 4.21)

- Earth Sciences (Tables 4.5, 4.13, 4.22)

- Accounting & Management Information Systems (Tables 4.6, 4.14, 4.23)

- Management & Marketing (Tables 4.7, 4.15, 4.24)

- Finance & Economics (Tables 4.8, 4.16, 4.25)

4.1 Data for Generating Section and Faculty Constraints

Constraints are to be generated for each section and faculty member as described in Chapter 3. The sections are numbered in a 3-digit format for convenience as shown in Table 4.1. Each section number in the column 1 is used to generate constraints by using it as input for codes 1 and 2 shown in the Appendix. The numbers in the last column of the table are used as input in codes 1, 2, and 4 shown in the Appendix to generate the faculty constraints.

The data received from the Registrar Office also contained sections which were not assigned (STAFF, TBA) to any of the faculty member. So each of these courses is assumed to be assigned to a distinct faculty member resulting in an individual constraint for each section. The actual assignment of the faculty member can be done after getting a feasible schedule for the model. This is done by the departments who assign these sections to faculty.

A sample data of the departments in the Group I for generating the section and faculty constraints is presented where the data is sorted by the Faculty Name.

Table 4.1: SE Sections (001 – 069)
Data for generating section and faculty constraints
(Sorted by Faculty Name)

Sec	Course	Faculty Name				Sec	Course	Faculty Name			
001	SE-100-01	AKHTAR S	S2	30		036	SE-448-01	BEN DAYA	S3	35	036
002	SE-100-51	AKHTAR S	S4	30		037	SE-207-01	CHEDED L	S2	30	
003	SE-302-51	AKHTAR S	S4	15		038	SE-432-01	CHEDED L	S2	30	
004	SE-302-52	AKHTAR S	S4	15		039	SE-207-52	CHEDED L	S4	15	039
005	SE-302-53	AKHTAR S	S4	15		040	SE-303-01	DARWESH	S1	30	
006	SE-302-54	AKHTAR S	S4	15	006	041	SE-325-01	DARWESH	S1	35	
007	SE-301-01	AL-AMER S	S1	30		042	SE-303-51	DARWESH	S4	30	042
008	SE-302-01	AL-AMER S	S1	15		043	SE-205-01	DUFFUAA S	S2	30	
009	SE-302-02	AL-AMER S	S1	15	009	044	SE-305-01	DUFFUAA S	S2	35	
010	SE-303-02	AL-FARES H	S1	30		045	SE-205-51	DUFFUAA S	S4	30	
011	SE-402-01	AL-FARES H	S3	35		046	SE-305-51	DUFFUAA S	S4	18	046
012	SE-303-52	AL-FARES H	S4	30	012	047	SE-461-01	EL-FERIK S	S2	25	
013	SE-320-01	AL-GHAMDI	S1	30		048	SE-301-08	EL-FERIK S	S1	30	
014	SE-325-02	AL-GHAMDI	S1	35	014	049	SE-461-51	EL-FERIK S	S4	25	049
015	SE-405-01	HABBOUBI M	S2	30		050	SE-301-06	NASSIF S	S1	30	
016	SE-443-01	HABBOUBI M	S2	40		051	SE-301-07	NASSIF S	S1	30	051
017	SE-443-51	HABBOUBI M	S4	40	017	052	SE-100-02	NAZEER	S2	30	
018	SE-207-02	AL-SAIF A	S2	30		053	SE-100-52	NAZEER	S4	30	053
019	SE-311-01	AL-SAIF A	S2	20		054	SE-207-51	RIYAZ H	S4	15	
020	SE-207-53	AL-SAIF A	S4	15	020	055	SE-207-54	RIYAZ H	S4	15	
021	SE-302-03	AL-SUNNI F	S1	15		056	SE-401-51	RIYAZ H	S4	15	
022	SE-302-04	AL-SUNNI F	S1	15	022	057	SE-401-52	RIYAZ H	S4	15	
023	SE-201-01	ANAS VAQAR	S2	30		058	SE-401-53	RIYAZ H	S4	15	
024	SE-201-02	ANAS VAQAR	S2	30		059	SE-401-54	RIYAZ H	S4	15	059
025	SE-311-51	ANAS VAQAR	S4	10		060	SE-205-02	SELIM S	S2	30	
026	SE-311-52	ANAS VAQAR	S4	10	026	061	SE-205-52	SELIM S	S4	30	061
027	SE-405-02	ANDIJANI A	S2	30		062	SE-401-02	SHABAIK H	S2	30	
028	SE-320-02	ANDIJANI A	S3	30	028	063	SE-301-02	SHABAIK H	S1	30	063
029	SE-100-03	ARIFUSALAM	S2	30		064	SE-301-04	SHAFIQ M	S1	30	
030	SE-100-53	ARIFUSALAM	S4	30		065	SE-315-01	SHAFIQ M	S3	20	065
031	SE-405-51	ARIFUSALAM	S4	30		066	SE-301-03	SHETA A	S1	30	
032	SE-405-52	ARIFUSALAM	S4	30	032	067	SE-301-09	SHETA A	S1	30	067
033	SE-465-01	AYAR T	S1	40		068	SE-401-01	TOKER O	S2	30	
034	SE-402-02	AYAR T	S3	35	034	069	SE-301-05	TOKER O	S1	30	069
035	SE-320-03	BEN DAYA M	S3	30							

Table 4.2: ICS Sections (070 – 176)
Data for generating section and faculty constraints
(Sorted by Faculty Name)

Sec	Course-Sec	Faculty Name	Hr	Enr	
070	ICS-201-05	ABUOSBA M	S1	27	
071	ICS-201-07	ABUOSBA M	S1	27	
072	ICS-201-54	ABUOSBA M	S4	22	
073	ICS-201-59	ABUOSBA M	S4	22	073
074	ICS-381-01	AHMED M	S1	25	
075	ICS-413-01	AHMED M	S1	30	075
076	ICS-201-06	AIYAZ H	S1	27	
077	ICS-201-09	AIYAZ H	S1	24	
078	ICS-201-52	AIYAZ H	S4	22	
079	ICS-201-60	AIYAZ H	S4	22	079
080	ICS-353-03	AL-BASSAM S	S1	25	080
081	ICS-101-04	SUGHAYER M	S2	30	081
082	ICS-411-01	SUKAIRY A	S2	25	
083	ICS-411-51	SUKAIRY A	S4	25	
084	ICS-434-01	SUKAIRY A	S1	25	084
085	ICS-252-02	SUWAIYEL M	S1	25	
086	ICS-353-02	SUWAIYEL M	S1	25	086
087	ICS-101-05	YOUSEF A	S2	30	
088	ICS-101-09	YOUSEF A	S2	30	
089	ICS-101-11	YOUSEF A	S2	30	089
090	ICS-201-03	AREF M	S1	27	
091	ICS-313-03	AREF M	S1	25	091
092	ICS-334-52	ASLAM M	S4	17	
093	ICS-334-53	ASLAM M	S4	17	093
094	ICS-102-07	BADHUSHA A	S2	27	
095	ICS-102-51	BADHUSHA A	S4	22	
096	ICS-102-53	BADHUSHA A	S4	22	
097	ICS-102-56	BADHUSHA A	S4	22	097
098	ICS-202-03	DARWISH N	S1	25	
099	ICS-432-01	DARWISH N	S1	30	099
100	ICS-101-51	ELISH M	S4	22	
101	ICS-101-52	ELISH M	S4	22	
102	ICS-101-53	ELISH M	S4	22	
103	ICS-201-57	ELISH M	S4	22	103
104	ICS-101-01	FAISAL K	S2	30	
105	ICS-101-02	FAISAL K	S2	30	105
106	ICS-201-02	GAROUT Y	S1	27	
107	ICS-201-04	GAROUT Y	S1	27	
108	ICS-201-53	GAROUT Y	S4	22	
109	ICS-201-58	GAROUT Y	S4	22	109
110	ICS-102-02	GHANDI B	S2	27	
111	ICS-102-52	GHANDI B	S4	22	
112	ICS-102-54	GHANDI B	S4	22	
113	ICS-102-55	GHANDI B	S4	22	
114	ICS-202-01	GHANDI B	S1	25	
115	ICS-202-04	GHANDI B	S1	25	115
116	ICS-252-03	GHANTA S	S1	25	116
117	ICS-252-01	JAOUA A	S1	25	
118	ICS-353-01	JAOUA A	S1	25	118
119	ICS-102-03	JUNAIDU S	S2	27	
120	ICS-102-08	JUNAIDU S	S2	27	
121	ICS-251-01	JUNAIDU S	S1	25	
122	ICS-251-02	JUNAIDU S	S1	25	122
123	ICS-102-05	LAHOURI G	S2	27	
124	ICS-102-06	LAHOURI G	S2	27	
125	ICS-102-59	LAHOURI G	S4	20	
126	ICS-102-60	LAHOURI G	S4	20	126
127	ICS-334-01	MAGHRABI T	S1	25	127
128	ICS-102-01	MAJED A	S2	27	
129	ICS-102-04	MAJED A	S2	27	
130	ICS-413-51	MAJED A	S4	15	
131	ICS-413-52	MAJED A	S4	15	131
132	ICS-102-57	SAID M	S4	22	
133	ICS-102-58	SAID M	S4	22	
134	ICS-201-01	SAID M	S1	27	
135	ICS-201-08	SAID M	S1	27	
136	ICS-202-02	SAID M	S1	25	
137	ICS-232-01	SAID M	S1	30	
138	ICS-232-51	SAID M	S4	15	
139	ICS-232-52	SAID M	S4	15	139
140	ICS-354-01	SARFRAZ M	S1	25	140
141	ICS-412-01	SHAFIQUE M	S3	25	
142	ICS-431-03	SHAFIQUE M	S1	25	
143	ICS-434-02	SHAFIQUE M	S1	25	143
144	ICS-334-51	SIDDIQUI A	S4	17	144
145	ICS-101-03	SIDDIQUI M	S2	30	
146	ICS-101-55	SIDDIQUI M	S4	22	146
147	ICS-201-51	STAFF -	S4	22	
148	ICS-201-55	STAFF -	S4	22	
149	ICS-201-56	STAFF -	S4	22	
150	ICS-201-61	STAFF -	S4	18	150
151	ICS-232-02	STAFF -	S1	30	151
152	ICS-251-03	STAFF -	S1	30	152
153	ICS-252-04	STAFF -	S1	30	153
154	ICS-313-01	STAFF -	S1	25	
155	ICS-313-02	STAFF -	S1	25	155
156	ICS-334-02	STAFF -	S1	25	
157	ICS-334-03	STAFF -	S1	30	157
158	ICS-353-04	STAFF -	S1	25	158
159	ICS-431-51	STAFF -	S4	25	
160	ICS-431-52	STAFF -	S4	25	
161	ICS-431-53	STAFF -	S4	25	161
162	ICS-432-51	STAFF -	S4	15	
163	ICS-432-52	STAFF -	S4	15	163
164	ICS-101-54	TBA L	S4	22	
165	ICS-101-59	TBA L	S4	22	165
166	ICS-101-60	TBA L	S4	22	
167	ICS-101-61	TBA L	S4	22	167
168	ICS-101-63	TBA L	S4	22	
169	ICS-101-66	TBA L	S4	22	169

Table 4.4: ME-AE Sections (232 - 391)
Data for generating section and faculty constraints
(Sorted by Faculty Name)

Seq	Course-Sec	Faculty Name	Hr	Enrl		Seq	Course-Sec	Faculty Name	Hr	Enrl	
232	ME-206-03	ABDUL ALEEM	S1	17		282	SE-322-57	ANIS M	S4	6	
233	ME-206-05	ABDUL ALEEM	S1	17		283	ME-482-52	ANIS M	S4	15	283
234	ME-206-53	ABDUL ALEEM	S4	9		284	ME-315-05	ANTAR M	S1	20	
235	SE-322-03	ABDUL ALEEM	S1	8		285	ME-440-01	ANTAR M	S1	25	285
236	SE-322-05	ABDUL ALEEM	S1	8		286	ME-307-02	ARIF A	S1	25	
237	SE-322-53	ABDUL ALEEM	S4	6	237	287	ME-307-03	ARIF A	S1	25	
238	ME-306-53	ABDUL SAMAD	S4	15		288	ME-308-05	ARIF A	S1	25	288
239	ME-306-56	ABDUL SAMAD	S4	15		289	ME-413-55	AYINDE T	S4	15	289
240	ME-308-52	ABDUL SAMAD	S4	15		290	ME-311-03	BADR H	S1	20	
241	ME-308-57	ABDUL SAMAD	S4	15	241	291	ME-311-05	BADR H	S1	20	
242	ME-413-56	ABIDOGUN K	S4	15	242	292	ME-438-01	BADR H	S3	30	292
243	ME-203-04	HAMAYEL H	S1	20		293	ME-403-51	BAZOUNE A	S4	16	
244	ME-311-04	HAMAYEL H	S1	20	244	294	ME-413-51	BAZOUNE A	S4	15	
245	ME-215-05	AHMAD Z	S3	25		295	ME-413-52	BAZOUNE A	S4	15	
246	ME-472-02	AHMAD Z	S1	30	246	296	ME-413-57	BAZOUNE A	S4	15	296
247	ME-206-54	AHMED F	S4	9		297	ME-204-04	DINCER I	S1	20	297
248	SE-322-54	AHMED F	S4	6	248	298	ME-307-01	ELEICHE A	S1	25	
249	ME-206-51	AHMED M	S4	9		299	SE-322-02	ELEICHE A	S1	8	299
250	ME-210-01	AHMED M	S2	15		300	ME-204-01	SHAARAWI M	S1	20	
251	ME-210-01	AHMED M	S4	15		301	ME-436-03	SHAARAWI M	S1	30	301
252	SE-322-51	AHMED M	S4	6	252	302	ME-204-03	GANDHIDAS	S1	20	
253	AE-333-01	AHMED S	S1	25		303	ME-439-01	GANDHIDAS	S1	25	303
254	ME-203-08	AHMED S	S1	20		304	ME-413-02	HAMDAN M	S2	25	
255	ME-433-01	AHMED S	S1	30	255	305	ME-413-05	HAMDAN M	S2	25	
256	ME-309-02	AL-BEDOOR B	S1	25	256	306	ME-482-01	HAMDAN M	S2	30	306
257	AE-220-01	AL-GARNI A	S1	25		307	ME-311-07	HASAN M	S1	20	307
258	AE-426-01	AL-GARNI A	S1	25		308	ME-215-53	HUSSAINI I	S4	15	
259	ME-320-01	AL-GARNI A	S1	25		309	ME-316-01	HUSSAINI I	S4	15	
260	ME-426-01	AL-GARNI A	S1	24	260	310	ME-316-05	HUSSAINI I	S4	15	310
261	ME-435-51	Al-GHATANI	S4	30	261	311	ME-215-54	IQBAL M	S4	15	
262	ME-309-01	AL-KAABI S	S1	25		312	ME-316-06	IQBAL M	S4	15	
263	ME-309-05	AL-KAABI S	S1	25	263	313	ME-316-07	IQBAL M	S4	15	313
264	ME-205-04	ALLAM I	S2	25		314	ME-201-01	KALYON M	S1	25	
265	ME-215-02	ALLAM I	S3	25	265	315	ME-201-02	KALYON M	S1	25	
266	ME-201-03	AL-NASSAR Y	S1	25		316	ME-413-01	KALYON M	S2	25	316
267	ME-201-04	AL-NASSAR Y	S1	25	267	317	ME-316-02	KHAN J	S4	15	
268	ME-203-10	AL-QUTUB A	S1	20		318	ME-316-04	KHAN J	S4	15	
269	ME-311-02	AL-QUTUB A	S1	20	269	319	ME-438-52	KHAN J	S4	15	319
270	ME-308-51	ZAHARNAH I	S4	15		320	ME-205-54	KHAN M	S4	15	
271	ME-403-56	ZAHARNAH I	S4	16		321	ME-215-52	KHAN M	S4	15	
272	ME-413-53	ZAHARNAH I	S4	15		322	ME-215-58	KHAN M	S4	15	
273	ME-413-54	ZAHARNAH I	S4	15		323	ME-215-59	KHAN M	S4	15	323
274	ME-413-58	ZAHARNAH I	S4	15	274	324	ME-215-07	KHAN Z	S3	25	324
275	ME-206-52	ANIS M	S4	9		325	ME-206-02	KHRAISHEH	S1	17	
276	ME-206-55	ANIS M	S4	9		326	ME-307-04	KHRAISHEH	S1	25	326
277	ME-206-56	ANIS M	S4	9		327	AE-328-01	KHULIEF Y	S1	25	
278	ME-206-57	ANIS M	S4	9		328	ME-413-03	KHULIEF Y	S2	25	
279	SE-322-52	ANIS M	S4	6		329	ME-413-04	KHULIEF Y	S2	25	
280	SE-322-55	ANIS M	S4	6		330	ME-428-01	KHULIEF Y	S1	30	330
281	SE-322-56	ANIS M	S4	6		331	ME-203-06	MAHFOZ F	S1	20	

Table 4.6: ACCT-MIS Sections (420 – 479)
Data for generating section and faculty constraints
(Sorted by Faculty Name)

Sec	Course Sec	Faculty Name	Time	Cap	Pre
420	ACCT-201-01	AHMED M	S2	30	
421	ACCT-201-51	AHMED M	S4	30	
422	ACCT-201-02	AHMED M	S2	30	
423	ACCT-201-52	AHMED M	S4	30	
424	ACCT-201-05	AHMED M	S2	30	
425	ACCT-201-55	AHMED M	S4	30	425
426	ACCT-201-03	RUMAIHI J	S2	30	
427	ACCT-201-53	RUMAIHI J	S4	30	
428	ACCT-201-04	RUMAIHI J	S2	30	
429	ACCT-201-54	RUMAIHI J	S4	30	429
430	ACCT-301-01	TUWAIJRI S	S3	30	
431	ACCT-403-01	TUWAIJRI S	S3	30	431
432	ACCT-202-02	MADANI H	S2	30	
433	ACCT-202-52	MADANI H	S4	30	
434	ACCT-401-01	MADANI H	S3	40	434
435	ACCT-406-01	MIRGHANI M	S3	30	435
436	ACCT-202-01	OWUSU-ANSA	S2	30	
437	ACCT-202-51	OWUSU-ANSA	S4	30	
438	ACCT-202-03	OWUSU-ANSA	S2	30	
439	ACCT-202-53	OWUSU-ANSA	S4	30	
440	ACCT-202-04	OWUSU-ANSA	S2	30	
441	ACCT-202-54	OWUSU-ANSA	S4	30	441
442	ACCT-404-01	SHUKRI W	S3	30	442
443	ACCT-202-05	STAFF -	S2	30	
444	ACCT-202-55	STAFF -	S4	30	444
445	ACCT-300-01	STAFF -	S2	30	
446	ACCT-300-51	STAFF -	S4	30	446
447	ACCT-405-01	WALLACE R	S3	35	447
448	MIS-490-01	ABDULGADER	S3	40	448
449	MIS-410-01	AL-JABRI I	S2	30	

Sec	Course Sec	Faculty Name	Time	Cap	Pre
450	MIS-410-51	AL-JABRI I	S4	30	450
451	MIS-215-01	AL-KHALDI	S3	45	
452	MIS-410-02	AL-KHALDI	S3	30	
453	MIS-410-52	AL-KHALDI	S4	30	453
454	MIS-499-01	AL-KHATIB	S3	40	454
455	MIS-105-01	IRFAN A	S2	25	
456	MIS-105-51	IRFAN A	S4	25	
457	MIS-105-02	IRFAN A	S2	25	
458	MIS-105-52	IRFAN A	S4	25	
459	MIS-105-04	IRFAN A	S2	25	
460	MIS-105-54	IRFAN A	S4	25	
461	MIS-105-06	IRFAN A	S2	25	
462	MIS-105-56	IRFAN A	S4	25	462
463	MIS-215-03	KHAN I	S3	45	
464	MIS-215-04	KHAN I	S3	45	
465	MIS-401-01	KHAN I	S3	45	
466	MIS-401-02	KHAN I	S3	45	466
467	MIS-311-01	MENON G	S3	35	
468	MIS-311-02	MENON G	S3	35	468
469	MIS-420-01	MIRGHANI	S3	40	469
470	MIS-301-01	SHAHIDUL	S3	40	
471	MIS-301-02	SHAHIDUL	S3	40	
472	MIS-301-03	SHAHIDUL	S3	40	
473	MIS-302-01	SHAHIDUL	S3	40	473
474	MIS-215-02	SHAIKH N	S3	45	474
475	MIS-105-03	STAFF -	S2	25	
476	MIS-105-53	STAFF -	S4	25	476
477	MIS-105-05	STAFF -	S2	25	
478	MIS-105-55	STAFF -	S4	25	478
479	MIS-345-01	STAFF -	S3	40	479

Table 4.7: MGT-MKT Sections (480 – 516)
Data for generating section and faculty constraints
(Sorted by Faculty Name)

Sec	Course	Faculty Name	Hr	En	
480	MGT-410-01	ACHOUI M	S3	40	
481	MGT-415-01	ACHOUI M	S3	30	481
482	MGT-449-01	BURAEY M	S3	40	482
483	MGT-448-02	OWAID M	S3	40	483
484	MGT-449-02	SHAMMARI	S3	40	484
485	MGT-401-01	ZAMEL I	S3	30	485
486	MGT-448-01	ZAMEL K	S3	40	486
487	MGT-301-01	HAMMAD S	S1	40	
488	MGT-301-02	HAMMAD S	S1	40	
489	MGT-301-03	HAMMAD S	S3	40	489
490	MGT-420-01	KAYYAL A	S3	35	
491	OM-210-01	KAYYAL A	S3	40	491
492	MGT-210-01	MAGHRABI	S3	35	
493	MGT-210-02	MAGHRABI	S3	35	492
494	MGT-311-01	REFAAT W	S3	35	
495	MGT-311-02	REFAAT W	S3	35	494
496	MKT-345-01	MUHMIN A	S1	35	
497	MKT-345-02	MUHMIN A	S1	35	496
498	MKT-375-01	ABDALI O	S1	35	

Sec	Course	Faculty Name	Hr	En	
499	MKT-375-02	ABDALI O	S1	35	498
500	MKT-450-01	GHAMDI M	S1	40	499
501	MKT-420-01	COOPER J	S1	30	
502	MKT-420-02	COOPER J	S1	30	501
503	MKT-301-01	SHURIDA O	S1	40	
504	MKT-301-02	SHURIDA O	S1	40	503
505	MKT-301-03	STAFF -	S3	40	504
506	MKT-320-01	STAFF -	S3	40	
507	MKT-320-02	STAFF -	S3	40	506
508	MKT-375-03	STAFF -	S1	35	507
509	MKT-450-02	STAFF -	S1	40	508
510	OM-310-01	AL-FARAJ T	S3	40	509
511	OM-202-01	MULHEM A	S1	35	
512	OM-202-02	MULHEM A	S1	35	
513	OM-202-03	MULHEM A	S3	35	512
514	OM-201-01	SAMDAN A	S1	35	
515	OM-201-02	SAMDAN A	S1	35	514
516	OM-210-02	SUHAIMI A	S3	40	515

Table 4.8: FIN-ECON Sections (517 – 545)
Data for generating section and faculty constraints
(Sorted by Faculty Name)

Sec	Course	Faculty Name	Hr	En	
517	ECON-403-02	ABANDY H	S1	38	517
518	ECON-101-03	GHAMDI M	S1	40	
519	ECON-101-04	GHAMDI M	S1	40	
520	ECON-101-05	GHAMDI M	S1	40	520
521	ECON-202-01	HEJJI M	S1	35	
522	ECON-202-02	HEJJI M	S1	35	
523	ECON-305-01	HEJJI M	S1	35	523
524	ECON-202-03	CHOUDURY	S1	35	
525	ECON-202-04	CHOUDURY	S1	35	
526	ECON-403-01	CHOUDURY	S1	38	526
527	ECON-403-05	HAMDAN B	S3	38	
528	ECON-403-06	HAMDAN B	S3	38	
529	FIN-415-01	HAMDAN B	S3	35	529
530	ECON-410-01	OTHMAN O	S3	35	530
531	ECON-101-01	ROMERO R	S1	40	

Sec	Course	Faculty Name	Hr	En	
532	ECON-101-02	ROMERO R	S1	40	532
533	ECON-403-03	UMAR Y	S3	38	
534	ECON-403-04	UMAR Y	S3	38	534
535	ECON-306-01	YAMANI Z	S1	35	
536	ECON-306-02	YAMANI Z	S1	35	
537	ECON-415-01	YAMANI Z	S1	35	537
538	FIN-410-01	ABRAHAM	S3	35	538
539	FIN-420-01	AL-ELG A	S3	35	
540	FIN-430-01	AL-ELG A	S3	45	540
541	FIN-301-01	MUSA M	S3	35	
542	FIN-301-02	MUSA M	S3	35	542
543	FIN-421-01	RAHGOZAR	S3	30	543
544	FIN-302-01	SEYYED F	S3	35	544
545	FIN-301-03	UMAR Y	S3	35	545

Table 4.10: ICS Sections (070 – 176)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

077	ICS-201-09	AIYAZ H	S1	24		119	ICS-102-03	JUNAIDU S	S2	27
082	ICS-411-01	AL-SUKAIRY A	S2	25		120	ICS-102-08	JUNAIDU S	S2	27
141	ICS-412-01	SHAFIQUE M	S3	25		123	ICS-102-05	LAHOURI G	S2	27
174	ICS-490-01	TBA L	S3	25		124	ICS-102-06	LAHOURI G	S2	27
074	ICS-381-01	AHMED M	S1	25		128	ICS-102-01	MAJED A	S2	27
080	ICS-353-03	AL-BASSAM S	S1	25		129	ICS-102-04	MAJED A	S2	27
084	ICS-434-01	AL-SUKAIRY A	S1	25		070	ICS-201-05	ABUOSBA M	S1	27
085	ICS-252-02	SUWAIYEL M	S1	25		071	ICS-201-07	ABUOSBA M	S1	27
086	ICS-353-02	SUWAIYEL M	S1	25		076	ICS-201-06	AIYAZ H	S1	27
091	ICS-313-03	AREF M	S1	25		090	ICS-201-03	AREF M	S1	27
098	ICS-202-03	DARWISH N	S1	25		106	ICS-201-02	GAROUT Y	S1	27
114	ICS-202-01	GHANDI B	S1	25		107	ICS-201-04	GAROUT Y	S1	27
115	ICS-202-04	GHANDI B	S1	25		134	ICS-201-01	SAID M	S1	27
116	ICS-252-03	GHANTA S	S1	25		135	ICS-201-08	SAID M	S1	27
117	ICS-252-01	JAOUA A	S1	25		081	ICS-101-04	SUGHAYER M	S2	30
118	ICS-353-01	JAOUA A	S1	25		087	ICS-101-05	AL-YOUSEF A	S2	30
121	ICS-251-01	JUNAIDU S	S1	25		088	ICS-101-09	AL-YOUSEF A	S2	30
122	ICS-251-02	JUNAIDU S	S1	25		089	ICS-101-11	AL-YOUSEF A	S2	30
127	ICS-334-01	MAGHRABI T	S1	25		104	ICS-101-01	FAISAL K	S2	30
136	ICS-202-02	SAID M	S1	25		105	ICS-101-02	FAISAL K	S2	30
140	ICS-354-01	SARFRAZ M	S1	25		145	ICS-101-03	SIDDIQUI M	S2	30
142	ICS-431-03	SHAFIQUE M	S1	25		175	ICS-101-08	YAZDANI J	S2	30
143	ICS-434-02	SHAFIQUE M	S1	25		176	ICS-101-10	YAZDANI J	S2	30
154	ICS-313-01	STAFF -	S1	25		075	ICS-413-01	AHMED M	S1	30
155	ICS-313-02	STAFF -	S1	25		099	ICS-432-01	DARWISH N	S1	30
156	ICS-334-02	STAFF -	S1	25		137	ICS-232-01	SAID M	S1	30
158	ICS-353-04	STAFF -	S1	25		151	ICS-232-02	STAFF -	S1	30
172	ICS-431-01	TBA L	S1	25		152	ICS-251-03	STAFF -	S1	30
173	ICS-431-02	TBA L	S1	25		153	ICS-252-04	STAFF -	S1	30
094	ICS-102-07	BADHUSHA A	S2	27		157	ICS-334-03	STAFF -	S1	30
110	ICS-102-02	GHANDI B	S2	27						

Table 4.11: COE Sections (177 – 231)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

Sec	Course-Sec	Faculty Name	Rm	Enr
219	COE-400-02	KHAN S	S2	20
226	COE-400-01	RAAD M	S2	20
183	COE-200-11	AL-MULHEM A	S1	20
206	COE-200-05	HASAN M	S1	20
216	COE-200-12	KHAN S	S1	20
221	COE-200-03	MABROUKEH N	S1	20
222	COE-200-07	MABROUKEH N	S1	20
228	COE-200-09	SAIT S	S1	20
181	COE-305-03	AL-MOHAMED M	S1	25
182	COE-484-01	AL-MOHAMED M	S1	25
184	COE-442-02	AL-MULHEM A	S1	25
185	COE-442-04	AL-MULHEM A	S1	25
186	COE-305-02	AL-NAJJAR A	S1	25
188	COE-360-02	AMIN A	S1	25
189	COE-360-03	AMIN A	S1	25
196	COE-342-01	CAM H	S1	25

Sec	Course-Sec	Faculty Name	Rm	Enr
198	COE-205-03	EL-MALEH A	S1	25
205	COE-200-02	HASAN M	S1	25
213	COE-205-02	KHAN M	S1	25
214	COE-442-03	KHAN M	S1	25
225	COE-200-01	RAAD M	S1	25
230	COE-342-02	YOUSSEF H	S1	25
177	COE-308-02	ABDEL-AAL R	S3	27
178	COE-308-01	ABD-EL-BARR M	S3	27
190	COE-449-01	ASHRAF F	S1	30
197	COE-441-01	CAM H	S1	30
199	COE-205-04	EL-MALEH A	S1	30
231	COE-353-01	ZAHIR S	S1	30
179	COE-390-01	ABD-EL-BARR M	S2	35
207	COE-390-02	IBRAHIM M	S2	35
215	COE-485-01	KHAN M	S1	40

Table 4.12: ME-AE Sections (232 - 391)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

Sec	Course-Sec	Faculty Name	Rm	Enr
235	SE-322-03	ABDUL ALEEM	S1	8
236	SE-322-05	ABDUL ALEEM	S1	8
299	SE-322-02	ELEICHE A	S1	8
376	SE-322-01	SPUZIC S	S1	8
377	SE-322-04	SPUZIC S	S1	8
250	ME-210-01	AHMED M	S2	15
348	ME-210-03	O'BRIEN J	S2	15
350	ME-210-04	O'BRIEN J	S2	15
388	ME-210-02	YOUNAS M	S2	15
232	ME-206-03	ABDUL ALEEM	S1	17
233	ME-206-05	ABDUL ALEEM	S1	17
325	ME-206-02	KHRAISHEH M	S1	17
373	ME-206-01	SPUZIC S	S1	17
374	ME-206-04	SPUZIC S	S1	17
243	ME-203-04	HAMAYEL H	S1	20
244	ME-311-04	HAMAYEL H	S1	20
254	ME-203-08	AHMED S	S1	20
268	ME-203-10	AL-QUTUB A	S1	20
269	ME-311-02	AL-QUTUB A	S1	20
284	ME-315-05	ANTAR M	S1	20
290	ME-311-03	BADR H	S1	20
291	ME-311-05	BADR H	S1	20
297	ME-204-04	DINCER I	S1	20
300	ME-204-01	SHAARAWI	S1	20
302	ME-204-03	GANDHIDAS	S1	20
307	ME-311-07	HASAN M	S1	20

Sec	Course-Sec	Faculty Name	Rm	Enr
331	ME-203-06	MAHFOZ F	S1	20
332	ME-203-13	MAHFOZ F	S1	20
344	ME-203-09	MOKHEIMER	S1	20
360	ME-315-03	SAHIN A	S1	20
361	ME-315-04	SAHIN A	S1	20
371	ME-203-12	SHUJA S	S1	20
372	ME-315-06	SHUJA S	S1	20
380	ME-315-01	THOMAS L	S1	20
386	ME-204-05	YILBAS B	S1	20
390	ME-204-02	ZUBAIR S	S1	20
260	ME-426-01	AL-GARNI A	S1	24
264	ME-205-04	ALLAM I	S2	25
304	ME-413-02	HAMDAN M	S2	25
305	ME-413-05	HAMDAN M	S2	25
316	ME-413-01	KALYON M	S2	25
328	ME-413-03	KHULIEF Y	S2	25
329	ME-413-04	KHULIEF Y	S2	25
352	ME-205-02	QASEM Z	S2	25
353	ME-205-03	QASEM Z	S2	25
365	ME-306-04	SHEIKH A	S2	25
367	ME-306-01	SHUAIB A	S2	25
368	ME-306-03	SHUAIB A	S2	25
245	ME-215-05	AHMAD Z	S3	25
265	ME-215-02	ALLAM I	S3	25
324	ME-215-07	KHAN Z	S3	25
340	ME-215-03	MEZGHANI K	S3	25

Table 4.12: ME-AE Sections (232 - 391)   Continued...
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

341	ME-215-04	MEZGHANI K	S3	25		338	ME-308-02	MERAH N	S1	25
253	AE-333-01	AHMED S	S1	25		339	ME-308-03	MERAH N	S1	25
256	ME-309-02	AL-BEDOOR B	S1	25		362	ME-423-01	SAHIN A	S1	25
257	AE-220-01	AL-GARNI A	S1	25		369	ME-463-01	SHUAIB A	S1	25
258	AE-426-01	AL-GARNI A	S1	25		378	ME-309-03	SUNAR M	S1	25
259	ME-320-01	AL-GARNI A	S1	25		385	AE-325-01	YILBAS B	S1	25
262	ME-309-01	AL-KAABI S	S1	25		391	ME-437-01	ZUBAIR S	S1	25
263	ME-309-05	AL-KAABI S	S1	25		306	ME-482-01	HAMDAN M	S2	30
266	ME-201-03	AL-NASSAR Y	S1	25		364	ME-435-01	SAID S	S2	30
267	ME-201-04	AL-NASSAR Y	S1	25		292	ME-438-01	BADR H	S3	30
285	ME-440-01	ANTAR M	S1	25		246	ME-472-02	AHMAD Z	S1	30
286	ME-307-02	ARIF A	S1	25		255	ME-433-01	AHMED S	S1	30
287	ME-307-03	ARIF A	S1	25		301	ME-436-03	SHAARAWI M	S1	30
288	ME-308-05	ARIF A	S1	25		330	ME-428-01	KHULIEF Y	S1	30
298	ME-307-01	ELEICHE A	S1	25		363	ME-203-02	SAID S	S1	30
303	ME-439-01	GANDHIDAS	S1	25		366	ME-462-01	SHEIKH A	S1	30
314	ME-201-01	KALYON M	S1	25		370	ME-203-01	SHUJA S	S1	30
315	ME-201-02	KALYON M	S1	25		375	ME-471-01	SPUZIC S	S1	30
326	ME-307-04	KHRAISHEH	S1	25		387	ME-425-01	YILBAS B	S1	30
327	AE-328-01	KHULIEF Y	S1	25		379	ME-403-04	SUNAR M	S1	30
337	ME-308-01	MERAH N	S1	25						

Table 4.13: GEOL-GEOP Sections (392-419)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

415	GEOL-454-51	MAKKAWI M	S3	18		414	GEOL-454-01	MAKKAWI M	S1	24
401	GEOP-405-01	AL-SHAHEEL	S3	20		416	GEOP-202-01	QAHWASH A	S1	24
394	GEOL-305-01	AHMED Z	S2	24		418	GEOL-341-01	SAAFEEN A	S1	24
404	GEOL-201-01	GHALEB A	S2	24		392	GEOP-402-01	KHODHAIR A	S3	30
406	GEOL-203-01	GHALEB A	S2	24		398	GEOL-409-01	AL-SHAHEEL	S3	30
409	GEOL-311-01	IMMAM B	S2	24		402	GEOL-402-01	AL-SHAIBANI	S3	30
396	GEOL-350-01	AHMED Z	S3	24		411	GEOP-430-01	KORVIN G	S3	30
413	GEOP-455-01	KORVIN G	S3	24		399	GEOP-315-01	AL-SHAHEEL	S1	30
417	GEOP-450-01	QAHWASH	S3	24		419	GEOL-446-01	SAAFEEN A	S1	30
408	GEOL-415-01	HUSSAIN M	S1	24						

Table 4.14: ACCT-MIS Sections (420 – 479)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

Sec	Course	Faculty Name	Hrs	Enr		Sec	Course	Faculty Name	Hrs	Enr
455	MIS-105-01	IRFAN A	S2	25		442	ACCT-404-01	SHUKRI W	S3	30
457	MIS-105-02	IRFAN A	S2	25		452	MIS-410-02	AL-KHALDI	S3	30
459	MIS-105-04	IRFAN A	S2	25						
461	MIS-105-06	IRFAN A	S2	25		447	ACCT-405-01	WALLACE R	S3	35
475	MIS-105-03	STAFF -	S2	25		467	MIS-311-01	MENON G	S3	35
477	MIS-105-05	STAFF -	S2	25		468	MIS-311-02	MENON G	S3	35
420	ACCT-201-01	AHMED M	S2	30		434	ACCT-401-01	MADANI H	S3	40
422	ACCT-201-02	AHMED M	S2	30		448	MIS-490-01	ABDULGADER	S3	40
424	ACCT-201-05	AHMED M	S2	30		454	MIS-499-01	AL-KHATIB G	S3	40
426	ACCT-201-03	RUMAIHI J	S2	30		469	MIS-420-01	MIRGHANI M	S3	40
428	ACCT-201-04	RUMAIHI J	S2	30		470	MIS-301-01	SHAHIDUL	S3	40
432	ACCT-202-02	MADANI H	S2	30		471	MIS-301-02	SHAHIDUL	S3	40
436	ACCT-202-01	OWUSU-ANSA	S2	30		472	MIS-301-03	SHAHIDUL	S3	40
438	ACCT-202-03	OWUSU-ANSA	S2	30		473	MIS-302-01	SHAHIDUL	S3	40
440	ACCT-202-04	OWUSU-ANSA	S2	30		479	MIS-345-01	STAFF -	S3	40
443	ACCT-202-05	STAFF -	S2	30		451	MIS-215-01	AL-KHALDIM	S3	45
445	ACCT-300-01	STAFF -	S2	30		463	MIS-215-03	KHAN I	S3	45
449	MIS-410-01	AL-JABRI I	S2	30		464	MIS-215-04	KHAN I	S3	45
430	ACCT-301-01	TUWAIJRI S	S3	30		465	MIS-401-01	KHAN I	S3	45
431	ACCT-403-01	TUWAIJRI S	S3	30		466	MIS-401-02	KHAN I	S3	45
435	ACCT-406-01	MIRGHANI	S3	30		474	MIS-215-02	SHAIKH N	S3	45

Table 4.15: MGT-MKT Sections (480 – 516)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

Sec	Course	Faculty Name	Hrs	Enr		Sec	Course	Faculty Name	Hrs	Enr
481	MGT-415-01	ACHOUI M	S3	30		515	OM-201-02	SAMDAN A	S1	35
485	MGT-401-01	ZAMEL I	S3	30		480	MGT-410-01	ACHOUI M	S3	40
501	MKT-420-01	COOPER J	S1	30		482	MGT-449-01	BURAEY M	S3	40
502	MKT-420-02	COOPER J	S1	30		483	MGT-448-02	OWAID M	S3	40
						484	MGT-449-02	SHAMMARI	S3	40
490	MGT-420-01	KAYYAL A	S3	35		486	MGT-448-01	AL-ZAMEL K	S3	40
492	MGT-210-01	MAGHRABI	S3	35		487	MGT-301-01	HAMMAD S	S1	40
493	MGT-210-02	MAGHRABI	S3	35		488	MGT-301-02	HAMMAD S	S1	40
494	MGT-311-01	REFAAT W	S3	35		489	MGT-301-03	HAMMAD S	S3	40
495	MGT-311-02	REFAAT W	S3	35		491	OM-210-01	KAYYAL A	S3	40
496	MKT-345-01	MUHMIN A	S1	35		500	MKT-450-01	GHAMDI M	S1	40
497	MKT-345-02	MUHMIN A	S1	35		503	MKT-301-01	SHURIDA O	S1	40
498	MKT-375-01	ABDALI O	S1	35		504	MKT-301-02	SHURIDA O	S1	40
499	MKT-375-02	ABDALI O	S1	35		505	MKT-301-03	STAFF -	S3	40
508	MKT-375-03	STAFF -	S1	35		506	MKT-320-01	STAFF -	S3	40
511	OM-202-01	MULHEM A	S1	35		507	MKT-320-02	STAFF -	S3	40
512	OM-202-02	MULHEM A	S1	35		509	MKT-450-02	STAFF -	S1	40
513	OM-202-03	MULHEM A	S3	35		510	OM-310-01	FARAJ T	S3	40
514	OM-201-01	SAMDAN A	S1	35		516	OM-210-02	SUHAIMI A	S3	40

Table 4.16: FIN-ECON Sections (517 – 545)
Data for generating Room constraints (Sorted by Enrollment)
(Classroom allocation for Lectures, Labs not included)

543	FIN-421-01	RAHGOZAR	S3	35		544	FIN-302-01	SEYYED F	S3	35
521	ECON-202-01	HEJJI M	S1	35		545	FIN-301-03	UMAR Y	S3	35
522	ECON-202-02	HEJJI M	S1	35		517	ECON-403-02	ABANDY H	S1	38
523	ECON-305-01	HEJJI M	S1	35		526	ECON-403-01	CHOUDURY	S1	38
524	ECON-202-03	CHOUDURY	S1	35		527	ECON-403-05	HAMDAN B	S3	38
525	ECON-202-04	CHOUDURY	S1	35		528	ECON-403-06	HAMDAN B	S3	38
529	FIN-415-01	HAMDAN B	S3	35		533	ECON-403-03	UMAR Y	S3	38
530	ECON-410-01	OTHMAN O	S3	35		534	ECON-403-04	UMAR Y	S3	38
535	ECON-306-01	YAMANI Z	S1	35		518	ECON-101-03	GHAMDI M	S1	40
536	ECON-306-02	YAMANI Z	S1	35		519	ECON-101-04	GHAMDI M	S1	40
537	ECON-415-01	YAMANI Z	S1	35		520	ECON-101-05	GHAMDI M	S1	40
538	FIN-410-01	ABRAHAM	S3	35		531	ECON-101-01	ROMERO R	S1	40
539	FIN-420-01	AL-ELG A	S3	35		532	ECON-101-02	ROMERO R	S1	40
541	FIN-301-01	MUSA M	S3	35		540	FIN-430-01	AL-ELG A	S3	45
542	FIN-301-02	MUSA M	S3	35						

4.3 Data for Generating Section Cluster Constraints

The sections in each department are grouped according to their levels and thus the data is sorted according to the levels as shown below. The constraints are generated using this data.

Table 4.18: SE Sections (001 – 069)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

Se#	Course-Sec	Teacher Name	Lvl		Se#	Course-Sec	Teacher Name	Lvl
001	SE-100-01	AKHTAR S	S2		041	SE-325-01	DARWESH M	S1
052	SE-100-02	NAZEERUDDIN	S2		014	SE-325-02	AL-GHAMDI A	S1
029	SE-100-03	ARIFUSALAM S	S2		044	SE-305-01	DUFFUAA S	S2
002	SE-100-51	AKHTAR S	S4		019	SE-311-01	AL-SAIF A	S2
053	SE-100-52	NAZEERUDDIN	S4		065	SE-315-01	SHAFIQ M	S3
030	SE-100-53	ARIFUSALAM S	S4		028	SE-320-02	ANDIJANI A	S3
					035	SE-320-03	BEN DAYA M	S3
023	SE-201-01	ANAS VAQAR S	S2		003	SE-302-51	AKHTAR S	S4
024	SE-201-02	ANAS VAQAR S	S2		004	SE-302-52	AKHTAR S	S4
043	SE-205-01	DUFFUAA S	S2		005	SE-302-53	AKHTAR S	S4
060	SE-205-02	SELIM S	S2		006	SE-302-54	AKHTAR S	S4
037	SE-207-01	CHEDED L	S2		042	SE-303-51	DARWESH M	S4
018	SE-207-02	AL-SAIF A	S2		012	SE-303-52	AL-FARES H	S4
045	SE-205-51	DUFFUAA S	S4		046	SE-305-51	DUFFUAA S	S4
061	SE-205-52	SELIM S	S4		025	SE-311-51	ANAS VAQAR	S4
054	SE-207-51	RIYAZ H	S4		026	SE-311-52	ANAS VAQAR	S4
039	SE-207-52	CHEDED L	S4					
020	SE-207-53	AL-SAIF A	S4		033	SE-465-01	AYAR T	S1
055	SE-207-54	RIYAZ H	S4		068	SE-401-01	TOKER O	S2
					062	SE-401-02	SHABAIK H	S2
007	SE-301-01	AL-AMER S	S1		015	SE-405-01	HABBOUBI M	S2
063	SE-301-02	SHABAIK H	S1		027	SE-405-02	ANDIJANI A	S2
066	SE-301-03	SHETA A	S1		038	SE-432-01	CHEDED L	S2
064	SE-301-04	SHAFIQ M	S1		016	SE-443-01	HABBOUBI M	S2
069	SE-301-05	TOKER O	S1		047	SE-461-01	EL-FERIK S	S2
050	SE-301-06	NASSIF S	S1		011	SE-402-01	AL-FARES H	S3
051	SE-301-07	NASSIF S	S1		034	SE-402-02	AYAR T	S3
048	SE-301-08	EL-FERIK S	S1		036	SE-448-01	BEN DAYA M	S3
067	SE-301-09	SHETA A	S1		056	SE-401-51	RIYAZ H	S4
008	SE-302-01	AL-AMER S	S1		057	SE-401-52	RIYAZ H	S4
009	SE-302-02	AL-AMER S	S1		058	SE-401-53	RIYAZ H	S4
021	SE-302-03	AL-SUNNI F	S1		059	SE-401-54	RIYAZ H	S4
022	SE-302-04	AL-SUNNI F	S1		031	SE-405-51	ARIFUSALAM S	S4
040	SE-303-01	DARWESH M	S1		032	SE-405-52	ARIFUSALAM S	S4
010	SE-303-02	AL-FARES H	S1		017	SE-443-51	HABBOUBI M	S4
013	SE-320-01	AL-GHAMDI A	S1		049	SE-461-51	EL-FERIK S	S4

Table 4.19: ICS Sections (070 – 176)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

104	ICS-101-01	FAISAL K	S2	077	ICS-201-09	AIYAZ H	S1
105	ICS-101-02	FAISAL K	S2	114	ICS-202-01	GHANDI B	S1
145	ICS-101-03	SIDDIQUI M	S2	136	ICS-202-02	SAID M	S1
081	ICS-101-04	AL-SUGHAYYER M	S2	098	ICS-202-03	DARWISH N	S1
087	ICS-101-05	AL-YOUSEF A	S2	115	ICS-202-04	GHANDI B	S1
175	ICS-101-08	YAZDANI J	S2	137	ICS-232-01	SAID M	S1
088	ICS-101-09	AL-YOUSEF A	S2	151	ICS-232-02	STAFF -	S1
176	ICS-101-10	YAZDANI J	S2	121	ICS-251-01	JUNAIDU S	S1
089	ICS-101-11	AL-YOUSEF A	S2	122	ICS-251-02	JUNAIDU S	S1
128	ICS-102-01	MAJED A	S2	152	ICS-251-03	STAFF -	S1
110	ICS-102-02	GHANDI B	S2	117	ICS-252-01	JAOUA A	S1
119	ICS-102-03	JUNAIDU S	S2	085	ICS-252-02	AL-SUWAIYEL M	S1
129	ICS-102-04	MAJED A	S2	116	ICS-252-03	GHANTA S	S1
123	ICS-102-05	LAHOURI G	S2	153	ICS-252-04	STAFF -	S1
124	ICS-102-06	LAHOURI G	S2	147	ICS-201-51	STAFF -	S4
094	ICS-102-07	BADHUSHA A	S2	078	ICS-201-52	AIYAZ H	S4
120	ICS-102-08	JUNAIDU S	S2	108	ICS-201-53	GAROUT Y	S4
100	ICS-101-51	ELISH M	S4	072	ICS-201-54	ABUOSBA M	S4
101	ICS-101-52	ELISH M	S4	148	ICS-201-55	STAFF -	S4
102	ICS-101-53	ELISH M	S4	149	ICS-201-56	STAFF -	S4
164	ICS-101-54	TBA L	S4	103	ICS-201-57	ELISH M	S4
146	ICS-101-55	SIDDIQUI M	S4	109	ICS-201-58	GAROUT Y	S4
165	ICS-101-59	TBA L	S4	073	ICS-201-59	ABUOSBA M	S4
166	ICS-101-60	TBA L	S4	079	ICS-201-60	AIYAZ H	S4
167	ICS-101-61	TBA L	S4	150	ICS-201-61	STAFF -	S4
168	ICS-101-63	TBA L	S4	138	ICS-232-51	SAID M	S4
169	ICS-101-66	TBA L	S4	139	ICS-232-52	SAID M	S4
170	ICS-101-67	TBA L	S4				
171	ICS-101-68	TBA L	S4	154	ICS-313-01	STAFF -	S1
095	ICS-102-51	BADHUSHA A	S4	155	ICS-313-02	STAFF -	S1
111	ICS-102-52	GHANDI B	S4	091	ICS-313-03	AREF M	S1
096	ICS-102-53	BADHUSHA A	S4	127	ICS-334-01	MAGHRABI T	S1
112	ICS-102-54	GHANDI B	S4	156	ICS-334-02	STAFF -	S1
113	ICS-102-55	GHANDI B	S4	157	ICS-334-03	STAFF -	S1
097	ICS-102-56	BADHUSHA A	S4	118	ICS-353-01	JAOUA A	S1
132	ICS-102-57	SAID M	S4	086	ICS-353-02	AL-SUWAIYEL M	S1
133	ICS-102-58	SAID M	S4	080	ICS-353-03	AL-BASSAM S	S1
125	ICS-102-59	LAHOURI G	S4	158	ICS-353-04	STAFF -	S1
126	ICS-102-60	LAHOURI G	S4	140	ICS-354-01	SARFRAZ M	S1
				074	ICS-381-01	AHMED M	S1
134	ICS-201-01	SAID M	S1	092	ICS-334-52	ASLAM M	S4
106	ICS-201-02	GAROUT Y	S1	093	ICS-334-53	ASLAM M	S4
090	ICS-201-03	AREF M	S1	144	ICS-334-51	SIDDIQUI A	S4
107	ICS-201-04	GAROUT Y	S1				
070	ICS-201-05	ABUOSBA M	S1	075	ICS-413-01	AHMED M	S1
076	ICS-201-06	AIYAZ H	S1	172	ICS-431-01	TBA L	S1
071	ICS-201-07	ABUOSBA M	S1	173	ICS-431-02	TBA L	S1
135	ICS-201-08	SAID M	S1	142	ICS-431-03	SHAFIQUE M	S1

Table 4.21: ME-AE Sections (232 - 391)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

Sec	Course-Sec	Faculty Name	PS		Sec	Course-Sec	Faculty Name	PS
314	ME-201-01	KALYON M	S1		389	ME-210-02	YOUNAS M	S4
315	ME-201-02	KALYON M	S1		349	ME-210-03	O'BRIEN J	S4
266	ME-201-03	AL-NASSAR Y	S1		351	ME-210-04	O'BRIEN J	S4
267	ME-201-04	AL-NASSAR Y	S1		321	ME-215-52	KHAN M	S4
370	ME-203-01	SHUJA S	S1		308	ME-215-53	HUSSAINI I	S4
363	ME-203-02	SAID S	S1		311	ME-215-54	IQBAL M	S4
243	ME-203-04	HAMAYEL H	S1		384	ME-215-56	YAQUB M	S4
331	ME-203-06	MAHFOZ F	S1		322	ME-215-58	KHAN M	S4
254	ME-203-08	AHMED S	S1		323	ME-215-59	KHAN M	S4
344	ME-203-09	MOKHEIMER E	S1					
268	ME-203-10	AL-QUTUB A	S1		298	ME-307-01	ELEICHE A	S1
371	ME-203-12	SHUJA S	S1		286	ME-307-02	ARIF A	S1
332	ME-203-13	MAHFOZ F	S1		287	ME-307-03	ARIF A	S1
300	ME-204-01	SHAARAWI	S1		326	ME-307-04	KHRAISHEH M	S1
390	ME-204-02	ZUBAIR S	S1		337	ME-308-01	MERAH N	S1
302	ME-204-03	GANDHIDAS	S1		338	ME-308-02	MERAH N	S1
297	ME-204-04	DINCER I	S1		339	ME-308-03	MERAH N	S1
386	ME-204-05	YILBAS B	S1		288	ME-308-05	ARIF A	S1
373	ME-206-01	SPUZIC S	S1		262	ME-309-01	AL-KAABI S	S1
325	ME-206-02	KHRAISHEH M	S1		256	ME-309-02	AL-BEDOOR B	S1
232	ME-206-03	ABDUL ALEEM	S1		378	ME-309-03	SUNAR M	S1
374	ME-206-04	SPUZIC S	S1		263	ME-309-05	AL-KAABI S	S1
233	ME-206-05	ABDUL ALEEM	S1		269	ME-311-02	AL-QUTUB A	S1
257	AE-220-01	AL-GARNI A	S1		290	ME-311-03	BADR H	S1
352	ME-205-02	QASEM Z	S2		244	ME-311-04	HAMAYEL H	S1
353	ME-205-03	QASEM Z	S2		291	ME-311-05	BADR H	S1
264	ME-205-04	ALLAM I	S2		307	ME-311-07	HASAN M	S1
250	ME-210-01	AHMED M	S2		380	ME-315-01	THOMAS L	S1
388	ME-210-02	YOUNAS M	S2		360	ME-315-03	SAHIN A	S1
348	ME-210-03	O'BRIEN J	S2		361	ME-315-04	SAHIN A	S1
350	ME-210-04	O'BRIEN J	S2		284	ME-315-05	ANTAR M	S1
265	ME-215-02	ALLAM I	S3		372	ME-315-06	SHUJA S	S1
340	ME-215-03	MEZGHANI K	S3		259	ME-320-01	AL-GARNI A	S1
341	ME-215-04	MEZGHANI K	S3		376	AE-322-01	SPUZIC S	S1
245	ME-215-05	AHMAD Z	S3		299	AE-322-02	ELEICHE A	S1
324	ME-215-07	KHAN Z	S3		235	AE-322-03	ABDUL ALEEM	S1
381	ME-205-51	YAQUB M	S4		377	AE-322-04	SPUZIC S	S1
345	ME-205-52	MUHAMMAD I	S4		236	AE-322-05	ABDUL ALEEM	S1
382	ME-205-53	YAQUB M	S4		385	AE-325-01	YILBAS B	S1
320	ME-205-54	KHAN M	S4		327	AE-328-01	KHULIEF Y	S1
383	ME-205-55	YAQUB M	S4		253	AE-333-01	AHMED S	S1
249	ME-206-51	AHMED M	S4		367	ME-306-01	SHUAIB A	S2
275	ME-206-52	ANIS M	S4		368	ME-306-03	SHUAIB A	S2
234	ME-206-53	ABDUL ALEEM	S4		365	ME-306-04	SHEIKH A	S2
247	ME-206-54	AHMED F	S4		334	ME-306-51	MAHMOOD M	S4
276	ME-206-55	ANIS M	S4		335	ME-306-52	MAHMOOD M	S4
277	ME-206-56	ANIS M	S4		238	ME-306-53	ABDUL SAMAD	S4
278	ME-206-57	ANIS M	S4		336	ME-306-55	MAHMOOD M	S4
358	ME-206-58	RAZA M	S4		239	ME-306-56	ABDUL SAMAD	S4
251	ME-210-01	AHMED M	S4		270	ME-308-51	ZAHARNAH	S4

Table 4.21: ME-AE Sections (232 - 391)   Cont...
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

240	ME-308-52	ABDUL SAMAD	S4		391	ME-437-01	ZUBAIR S	S1
354	ME-308-53	RASHID M	S4		303	ME-439-01	GANDHIDAS	S1
355	ME-308-54	RASHID M	S4		285	ME-440-01	ANTAR M	S1
356	ME-308-55	RASHID M	S4		366	ME-462-01	SHEIKH A	S1
357	ME-308-56	RASHID M	S4		369	ME-463-01	SHUAIB A	S1
241	ME-308-57	ABDUL SAMAD	S4		375	ME-471-01	SPUZIC S	S1
309	ME-316-01	HUSSAINI I	S4		246	ME-472-02	AHMAD Z	S1
317	ME-316-02	KHAN J	S4		316	ME-413-01	KALYON M	S2
346	ME-316-03	MUHAMMAD I	S4		304	ME-413-02	HAMDAN M	S2
318	ME-316-04	KHAN J	S4		328	ME-413-03	KHULIEF Y	S2
310	ME-316-05	HUSSAINI I	S4		329	ME-413-04	KHULIEF Y	S2
312	ME-316-06	IQBAL M	S4		305	ME-413-05	HAMDAN M	S2
313	ME-316-07	IQBAL M	S4		364	ME-435-01	SAID S	S2
347	ME-316-08	MUHAMMAD I	S4		306	ME-482-01	HAMDAN M	S2
252	AE-322-51	AHMED M	S4		292	ME-438-01	BADR H	S3
279	AE-322-52	ANIS M	S4		293	ME-403-51	BAZOUNE A	S4
237	AE-322-53	ABDUL ALEEM	S4		271	ME-403-56	ZAHARNAH	S4
248	AE-322-54	AHMED F	S4		342	AE-411-01	MOKHEIMER E	S4
280	AE-322-55	ANIS M	S4		343	AE-412-01	MOKHEIMER E	S4
281	AE-322-56	ANIS M	S4		294	ME-413-51	BAZOUNE A	S4
282	AE-322-57	ANIS M	S4		295	ME-413-52	BAZOUNE A	S4
359	AE-322-58	RAZA M	S4		272	ME-413-53	ZAHARNAH	S4
					273	ME-413-54	ZAHARNAH	S4
379	ME-403-04	SUNAR M	S1		289	ME-413-55	AYINDE T	S4
362	ME-423-01	SAHIN A	S1		242	ME-413-56	ABIDOGUN K	S4
387	ME-425-01	YILBAS B	S1		296	ME-413-57	BAZOUNE A	S4
258	AE-426-01	AL-GARNI A	S1		274	ME-413-58	ZAHARNAH	S4
260	ME-426-01	AL-GARNI A	S1		333	AE-420-01	MAHMOOD M	S4
330	ME-428-01	KHULIEF Y	S1		261	ME-435-51	GHAHTANI	S4
255	ME-433-01	AHMED S	S1		319	ME-438-52	KHAN J	S4
301	ME-436-03	SHAARAWI	S1		283	ME-482-52	ANIS M	S4

Table 4.22: GEOL-GEOP Sections (392-419)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

Sec	Course-Sec	Faculty Name	Prs	Sec	Course-Sec	Faculty Name	Prs
416	GEOP-202-01	QAHWASH	S1	408	GEOL-415-01	HUSSAIN M	S1
404	GEOL-201-01	GHALEB A	S2	419	GEOL-446-01	SAAFEEN A	S1
406	GEOL-203-01	GHALEB A	S2	414	GEOL-454-01	MAKKAWI M	S1
405	GEOL-201-51	GHALEB A	S4	392	GEOP-402-01	KHODHAIR A	S3
407	GEOL-203-51	GHALEB A	S4	402	GEOL-402-01	AL-SHAIBANI	S3
399	GEOP-315-01	AL-SHAHEEL	S1	401	GEOP-405-01	AL-SHAHEEL	S3
418	GEOL-341-01	SAAFEEN A	S1	398	GEOL-409-01	AL-SHAHEEL	S3
394	GEOL-305-01	AHMED Z	S2	411	GEOP-430-01	KORVIN G	S3
409	GEOL-311-01	IMMAM B	S2	417	GEOP-450-01	QAHWASH A	S3
396	GEOL-350-01	AHMED Z	S3	413	GEOP-455-01	KORVIN G	S3
395	GEOL-305-51	AHMED Z	S4	415	GEOL-454-51	MAKKAWI M	S3
410	GEOL-311-51	IMMAM B	S4	393	GEOP-402-51	KHODHAIR A	S4
400	GEOP-315-51	AL-SHAHEEL	S4	403	GEOL-402-51	AL-SHAIBANI	S4

Table 4.23: ACCT-MIS Sections (420 – 479)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

Sec	Course-Sec	Faculty Name	Prs	Sec	Course-Sec	Faculty Name	Prs
455	MIS-105-01	IRFAN A	S2	437	ACCT-202-51	OWUSU-ANSA	S4
457	MIS-105-02	IRFAN A	S2	433	ACCT-202-52	MADANI H	S4
475	MIS-105-03	STAFF -	S2	439	ACCT-202-53	OWUSU-ANSA	S4
459	MIS-105-04	IRFAN A	S2	441	ACCT-202-54	OWUSU-ANSA	S4
477	MIS-105-05	STAFF -	S2	444	ACCT-202-55	STAFF -	S4
461	MIS-105-06	IRFAN A	S2	445	ACCT-300-01	STAFF -	S2
456	MIS-105-51	IRFAN A	S4	430	ACCT-301-01	TUWAIJRI S	S3
458	MIS-105-52	IRFAN A	S4	470	MIS-301-01	SHAHIDUL	S3
476	MIS-105-53	STAFF -	S4	471	MIS-301-02	SHAHIDUL	S3
460	MIS-105-54	IRFAN A	S4	472	MIS-301-03	SHAHIDUL	S3
478	MIS-105-55	STAFF -	S4	473	MIS-302-01	SHAHIDUL	S3
462	MIS-105-56	IRFAN A	S4	467	MIS-311-01	MENON G	S3
420	ACCT-201-01	AHMED M	S2	468	MIS-311-02	MENON G	S3
422	ACCT-201-02	AHMED M	S2	479	MIS-345-01	STAFF -	S3
426	ACCT-201-03	RUMAIHI J	S2	446	ACCT-300-51	STAFF -	S4
428	ACCT-201-04	RUMAIHI J	S2				
424	ACCT-201-05	AHMED M	S2	449	MIS-410-01	AL-JABRI I	S2
436	ACCT-202-01	OWUSU-ANSA	S2	434	ACCT-401-01	MADANI H	S3
432	ACCT-202-02	MADANI H	S2	465	MIS-401-01	KHAN I	S3
438	ACCT-202-03	OWUSU-ANSA	S2	466	MIS-401-02	KHAN I	S3
440	ACCT-202-04	OWUSU-ANSA	S2	431	ACCT-403-01	TUWAIJRI S	S3
443	ACCT-202-05	STAFF -	S2	442	ACCT-404-01	SHUKRI W	S3
451	MIS-215-01	AL-KHALDI M	S3	447	ACCT-405-01	WALLACE R	S3
474	MIS-215-02	SHAIKH N	S3	435	ACCT-406-01	MIRGHANI	S3
463	MIS-215-03	KHAN I	S3	452	MIS-410-02	AL-KHALDI M	S3
464	MIS-215-04	KHAN I	S3	469	MIS-420-01	MIRGHANI M	S3
421	ACCT-201-51	AHMED M	S4	448	MIS-490-01	ABDULGADER	S3
423	ACCT-201-52	AHMED M	S4	454	MIS-499-01	AL-KHATIB G	S3
427	ACCT-201-53	AL-RUMAIHI J	S4	450	MIS-410-51	AL-JABRI I	S4
429	ACCT-201-54	AL-RUMAIHI J	S4	453	MIS-410-52	AL-KHALDI M	S4
425	ACCT-201-55	AHMED M	S4				

Table 4.24: MGT-MKT Sections (480 – 516)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

Sec	Course	Faculty Name	LP		Sec	Course	Faculty Name	LP
514	OM-201-01	SAMDAN A	S1		505	MKT-301-03	STAFF -	S3
515	OM-201-02	SAMDAN A	S1		510	OM-310-01	AL-FARAJ T	S3
511	OM-202-01	MULHEM A	S1		494	MGT-311-01	REFAAT W	S3
512	OM-202-02	MULHEM A	S1		495	MGT-311-02	REFAAT W	S3
513	OM-202-03	MULHEM A	S3		506	MKT-320-01	STAFF -	S3
491	OM-210-01	KAYYAL A	S3		507	MKT-320-02	STAFF -	S3
516	OM-210-02	SUHAIMI A	S3					
493	MGT-210-02	MAGHRABI A	S3		501	MKT-420-01	COOPER J	S1
492	MGT-210-01	MAGHRABI A	S3		502	MKT-420-02	COOPER J	S1
					500	MKT-450-01	GHAMDI M	S1
487	MGT-301-01	HAMMAD S	S1		509	MKT-450-02	STAFF -	S1
488	MGT-301-02	HAMMAD S	S1		485	MGT-401-01	AL-ZAMEL I	S3
503	MKT-301-01	SHURIDA O	S1		480	MGT-410-01	ACHOUI M	S3
504	MKT-301-02	SHURIDA O	S1		481	MGT-415-01	ACHOUI M	S3
496	MKT-345-01	MUHMIN A	S1		490	MGT-420-01	KAYYAL A	S3
497	MKT-345-02	MUHMIN A	S1		486	MGT-448-01	ZAMEL K	S3
498	MKT-375-01	ABDALI O	S1		483	MGT-448-02	OWAID M	S3
499	MKT-375-02	ABDALI O	S1		482	MGT-449-01	BURAEY M	S3
508	MKT-375-03	STAFF -	S1		484	MGT-449-02	SHAMMARI E	S3
489	MGT-301-03	HAMMAD S	S3					

Table 4.25: FIN-ECON Sections (517 – 545)
Data for generating Section Cluster constraints
(Sorted by Levels and Period Sets)

Sec	Course	Faculty Name	LP		Sec	Course	Faculty Name	LP
531	ECON-101-01	ROMERO R	S1		545	FIN-301-03	UMAR Y	S3
532	ECON-101-02	ROMERO R	S1		544	FIN-302-01	SEYYED F	S3
518	ECON-101-03	GHAMDI M	S1					
519	ECON-101-04	GHAMDI M	S1		526	ECON-403-01	CHOUDHURY	S1
520	ECON-101-05	GHAMDI M	S1		517	ECON-403-02	ABANDY H	S1
	—				537	ECON-415-01	YAMANI Z	S1
521	ECON-202-01	HEJJI M	S1		533	ECON-403-03	UMAR Y	S3
522	ECON-202-02	HEJJI M	S1		534	ECON-403-04	UMAR Y	S3
524	ECON-202-03	CHOUDHURY	S1		527	ECON-403-05	HAMDAN B	S3
525	ECON-202-04	CHOUDHURY	S1		528	ECON-403-06	HAMDAN B	S3
	—				530	ECON-410-01	OTHMAN O	S3
523	ECON-305-01	AL-HEJJI M	S1		538	FIN-410-01	ABRAHAM A	S3
535	ECON-306-01	YAMANI Z	S1		529	FIN-415-01	HAMDAN B	S3
536	ECON-306-02	YAMANI Z	S1		539	FIN-420-01	AL-ELG A	S3
541	FIN-301-01	MUSA M	S3		543	FIN-421-01	RAHGOZAR	S3
542	FIN-301-02	MUSA M	S3		540	FIN-430-01	AL-ELG A	S3

5.2 Faculty Constraints

The faculty constraints are generated using the section numbers (Table 4.1) of each faculty as a set and the corresponding period numbers in the overlapping sets described in Chapter 3 (Table 3.6) as the input in the codes 1, 2 and 4. Sample Constraints for a faculty member for all 44 overlapping sets are reproduced below. For example, the first constraint can be explained as follows: The sections 001-006 are taught by Mr. AKHTAR S. They can be assigned to either of the respective sections in each of the overlapping period set (Table 3.6).

1. $X001017 + X002049 + X003049 + X004049 + X005049 + X006049 <= 1;$

2. $X001018 + X002049 + X002050 + X003049 + X003050 + X004049 + X004050 + X005049 + X005050 + X006049 + X006050 <= 1;$

3. $X001018 + X002049 + X002050 + X003049 + X003050 + X004049 + X004050 + X005049 + X005050 + X006049 + X006050 <= 1;$

4. $X001019 + X002049 + X002050 + X002051 + X003049 + X003050 + X003051 + X004049 + X004050 + X004051 + X005049 + X005050 + X005051 + X006049 + X006050 + X006051 <= 1;$

5. $X001019 + X002049 + X002050 + X002051 + X003049 + X003050 + X003051 + X004049 + X004050 + X004051 + X005049 + X005050 + X005051 + X006049 + X006050 + X006051 <= 1;$

6. $X001020 + X002050 + X002051 + X003050 + X003051 + X004050 + X004051 + X005050 + X005051 + X006050 + X006051 <= 1;$

7. $X001020 + X002050 + X002051 + X003050 + X003051 + X004050 + X004051 + X005050 + X005051 + X006050 + X006051 <= 1;$

8. $X001021 + X002051 + X003051 + X004051 + X005051 + X006051 <= 1;$

9. $X001022 + X002052 + X003052 + X004052 + X005052 + X006052 <= 1;$

10. $X001023 + X002052 + X002053 + X003052 + X003053 + X004052 + X004053 +$
    $X005052 + X005053 + X006052 + X006053 <= 1;$

11. $X001024 + X002052 + X002053 + X003052 + X003053 + X004052 + X004053 +$
    $X005052 + X005053 + X006052 + X006053 <= 1;$

12. $X001017 + X002059 + X003059 + X004059 + X005059 + X006059 <= 1;$

13. $X001018 + X002059 + X002060 + X003059 + X003060 + X004059 + X004060 +$
    $X005059 + X005060 + X006059 + X006060 <= 1;$

14. $X001018 + X002059 + X002060 + X003059 + X003060 + X004059 + X004060 +$
    $X005059 + X005060 + X006059 + X006060 <= 1;$

15. $X001019 + X002059 + X002060 + X002061 + X003059 + X003060 + X003061 +$
    $X004059 + X004060 + X004061 + X005059 + X005060 + X005061 + X006059 +$
    $X006060 + X006061 <= 1;$

16. $X001019 + X002059 + X002060 + X002061 + X003059 + X003060 + X003061 +$
    $X004059 + X004060 + X004061 + X005059 + X005060 + X005061 + X006059 +$
    $X006060 + X006061 <= 1;$

17. $X001020 + X002060 + X002061 + X003060 + X003061 + X004060 + X004061 +$
    $X005060 + X005061 + X006060 + X006061 <= 1;$

18. $X001020 + X002060 + X002061 + X003060 + X003061 + X004060 + X004061 +$
    $X005060 + X005061 + X006060 + X006061 <= 1;$

19. $X001021 + X002061 + X003061 + X004061 + X005061 + X006061 <= 1;$

20. $X001022 + X002062 + X003062 + X004062 + X005062 + X006062 <= 1;$

33. X001016 + X002057 + X002058 + X003057 + X003058 + X004057 + X004058 + X005057 + X005058 + X006057 + X006058 <= 1;

34. X001009 + X002064 + X003064 + X004064 + X005064 + X006064 <= 1;

35. X001010 + X002064 + X002065 + X003064 + X003065 + X004064 + X004065 + X005064 + X005065 + X006064 + X006065 <= 1;

36. X001010 + X002064 + X002065 + X003064 + X003065 + X004064 + X004065 + X005064 + X005065 + X006064 + X006065 <= 1;

37. X001011 + X002064 + X002065 + X002066 + X003064 + X003065 + X003066 + X004064 + X004065 + X004066 + X005064 + X005065 + X005066 + X006064 + X006065 + X006066 <= 1;

38. X001011 + X002064 + X002065 + X002066 + X003064 + X003065 + X003066 + X004064 + X004065 + X004066 + X005064 + X005065 + X005066 + X006064 + X006065 + X006066 <= 1;

39. X001012 + X002065 + X002066 + X003065 + X003066 + X004065 + X004066 + X005065 + X005066 + X006065 + X006066 <= 1;

40. X001012 + X002065 + X002066 + X003065 + X003066 + X004065 + X004066 + X005065 + X005066 + X006065 + X006066 <= 1;

41. X001013 + X002066 + X003066 + X004066 + X005066 + X006066 <= 1;

42. X001014 + X002067 + X003067 + X004067 + X005067 + X006067 <= 1;

43. X001015 + X002067 + X002068 + X003067 + X003068 + X004067 + X004068 + X005067 + X005068 + X006067 + X006068 <= 1;

44. X001016 + X002067 + X002068 + X003067 + X003068 + X004067 + X004068 + X005067 + X005068 + X006067 + X006068 <= 1;

5.3   Room Constraints

The available classrooms in the vicinity of the departments (Buildings 22 & 24) in the Group I are listed in Table 4.17. The classrooms are grouped by their capacity as Small (≤ 30) and Large (<30) rooms. There are 37 small and 29 large classrooms available for Group I. Thus the sections have also to be sorted by their enrollment capacity. Constraints are to be generated for each of the sections (Labs are neglected) according to the capacity of the classroom located in the vicinity of the respective departments in the group as described in Chapter 3. Sample Room constraints for R_1 and R_2 for one period of each set of periods (S1, S2, S3)

5.3.1   Small Rooms R_1 (≤ 30) Rooms Available r_1 (37)

S1

X007001 + X008001 + X009001 + X010001 + X013001 + X021001 + X022001 +

X040001 + X048001 + X050001 + X051001 + X063001 + X064001 + X066001 +

X067001 + X069001 + X070001 + X071001 + X074001 + X075001 + X076001 +

X077001 + X080001 + X084001 + X085001 + X086001 + X090001 + X091001 +

X098001 + X099001 + X106001 + X107001 + X114001 + X115001 + X116001 +

X117001 + X118001 + X121001 + X122001 + X127001 + X134001 + X135001 +

X136001 + X137001 + X140001 + X142001 + X143001 + X151001 + X152001 +

X153001 + X154001 + X155001 + X156001 + X157001 + X158001 + X172001 +

X173001 + X181001 + X182001 + X183001 + X184001 + X185001 + X186001 +

X188001 + X189001 + X190001 + X196001 + X197001 + X198001 + X199001 +

X205001 + X206001 + X213001 + X214001 + X216001 + X221001 + X222001 +

X225001 + X228001 + X230001 + X231001 + X232001 + X233001 + X235001 +

X236001 + X243001 + X244001 + X246001 + X253001 + X254001 + X255001 +

X256001 + X257001 + X258001 + X259001 + X260001 + X262001 + X263001 +

X266001 + X267001 + X268001 + X269001 + X284001 + X285001 + X286001 +

X287001 + X288001 + X290001 + X291001 + X297001 + X298001 + X299001 +

X300001 + X301001 + X302001 + X303001 + X307001 + X314001 + X315001 +

X325001 + X326001 + X327001 + X330001 + X331001 + X332001 + X337001 +

X338001 + X339001 + X344001 + X360001 + X361001 + X362001 + X363001 +

X366001 + X369001 + X370001 + X371001 + X372001 + X373001 + X374001 +

X375001 + X376001 + X377001 + X378001 + X379001 + X380001 + X385001 +

X386001 + X387001 + X390001 + X391001 + X399001 + X408001 + X414001 +

X416001 + X418001 + X419001 + X501001 + X502001 <= 37;

S2

X001009 + X015009 + X018009 + X019009 + X023009 + X024009 + X027009 +

X029009 + X037009 + X038009 + X043009 + X047009 + X052009 + X060009 +

X062009 + X068009 + X081009 + X082009 + X087009 + X088009 + X089009 +

X094009 + X104009 + X105009 + X110009 + X119009 + X120009 + X123009 +

X124009 + X128009 + X129009 + X145009 + X175009 + X176009 + X219009 +

X226009 + X250009 + X264009 + X304009 + X305009 + X306009 + X316009 +

X328009 + X329009 + X348009 + X350009 + X352009 + X353009 + X364009 +

X365009 + X367009 + X368009 + X388009 + X394009 + X404009 + X406009 +

X409009 + X420009 + X422009 + X424009 + X426009 + X428009 + X432009 +

X436009 + X438009 + X440009 + X443009 + X445009 + X449009 + X455009 +

X457009 + X459009 + X461009 + X475009 + X477009 <= 37;

S3

$$X028025 + X035025 + X065025 + X141025 + X174025 + X177025 + X178025 +$$

$$X245025 + X265025 + X292025 + X324025 + X340025 + X341025 + X392025 +$$

$$X396025 + X398025 + X401025 + X402025 + X411025 + X413025 + X415025 +$$

$$X417025 + X430025 + X431025 + X435025 + X442025 + X452025 + X481025 +$$

$$X485025 <= 37;$$

5.3.2 Large Rooms R_2 (> 30) Rooms Available r_2 (29)

S1

$$X014001 + X033001 + X041001 + X215001 + X487001 + X488001 + X496001 +$$

$$X497001 + X498001 + X499001 + X500001 + X503001 + X504001 + X508001 +$$

$$X509001 + X511001 + X512001 + X514001 + X515001 + X517001 + X518001 +$$

$$X519001 + X520001 + X521001 + X522001 + X523001 + X524001 + X525001 +$$

$$X526001 + X531001 + X532001 + X535001 + X536001 + X537001 <= 29;$$

S2

$$X016009 + X044009 + X179009 + X207009 <= 29;$$

S3

$$X011025 + X034025 + X036025 + X434025 + X447025 + X448025 + X451025 +$$

$$X454025 + X463025 + X464025 + X465025 + X466025 + X467025 + X468025 +$$

$$X469025 + X470025 + X471025 + X472025 + X473025 + X474025 + X479025 +$$

$$X480025 + X482025 + X483025 + X484025 + X486025 + X489025 + X490025 +$$

$$X491025 + X492025 + X493025 + X494025 + X495025 + X505025 + X506025 +$$

$$X507025 + X510025 + X513025 + X516025 + X527025 + X528025 + X529025 +$$

X530025 + X533025 + X534025 + X538025 + X539025 + X540025 + X541025 + X542025 + X543025 + X544025 + X545025 <= 29;

5.4   Section Cluster Constraints

Sections of same level and any two consecutive levels have to be offered at different times to ensure choices of the faculty and time for the students. Sample cluster constraints for Systems Engineering (SE) department is reproduced below (Table 4.18).

5.4.1   Same Level

100 Level

S2(3)   X001009 + X029009 + X052009 <= 1;

S4(3)   X002049 + X030049 + X053049 <= 1;

200 Level

S2(6)   X023009 + X024009 +X043009 + X060009 + X037009 + X018009 <= 1;

S4(6)   X020049 + X039049 +X045049 + X054049 + X055049 + X061049 <= 1;

300 Level

S1(9)   X008001 + X009001 + X010001 + X013001 + X014001 + X021001 +

               X022001 + X040001 + X041001 <= 1;

S2(2)   X019009 + X044009 <= 1;

S3(3)   X028025 + X035025 + X065025 <= 1;

S4(9)   X003049 + X004049 + X005049 + X006049 + X012049 + X025049 +

               X026049 + X042049 + X046049 <= 1;

400 Level

S2(7)   X015009 + X016009 + X027009 + X038009 + X047009 + X062009 +

               X068009 <= 1;

S3(3)   X011025 + X034025 + X036025 <= 1;

S4(8) $X017049 + X031049 + X032049 + X049049 + X056049 + X057049 +$

$X058049 + X059049 <= 1;$

5.4.2   Consecutive Levels

SE Courses Continued

100 & 200 Levels

S2(9) $X001009 + X052009 + X029009 + X023009 + X024009 + X043009 +$

$X060009 + X037009 + X018009 <= 1;$

S4(9) $X002049 + X053049 + X030049 + X045049 + X061049 + X054049 +$

$X039049 + X020049 + X055049 <= 1;$

200 & 300 Levels

S2(8) $X023009 + X024009 + X043009 + X060009 + X037009 + X018009 +$

$X044009 + X019009 <= 1;$

S4(14) $X045049 + X061049 + X054049 + X039049 + X020049 + X055049 +$

$X003049 + X004049 + X005049 + X006049 + X012049 + X046049 +$

$X025049 + X026049 <= 1;$

300 & 400 Levels

S2(9) $X044009 + X019009 + X068009 + X062009 + X015009 + X027009 +$

$X038009 + X016009 + X047009 <= 1;$

S3(6) $X065025 + X028025 + X035025 + X011025 + X034025 + X036025 <= 1;$

S4(17) $X003049 + X004049 + X005049 + X006049 + X042049 + X012049 +$

$X046049 + X025049 + X026049 + X056049 + X057049 + X058049 +$

$X059049 + X031049 + X032049 + X017049 + X049049 <= 1;$

Chapter 6

Results and Conclusions

The whole process of generation of constraints described in Chapter 3 (Problem Formulation) was coded and different sets of constraints for four different criteria were considered and generated, resulting in a huge Integer programming model with 10266 constraints and 8493 variables.

The model generated was solved using LINGO, a highly sophisticated optimization tool in recent days, namely, which uses many sophisticated algorithms like branch-and-bound, mixed cuts, 0/1 cuts etc with the use of heuristics. LINGO has the capacity of solving problems of unlimited number of constraints with unlimited number of variables both integer and non-linear simultaneously.

6.1 Solution of the Integer Programming Problem

The solution of problem is translated into Table 6.1 which shows the days and start and finish times for each section

Figure 6.1, 6.2 shows the number of small and large classrooms used each day of the week graphically.

Table 6.1: Section timings produced by the integer linear program

001	SE	100	01	S2	SM	10.00	11.00
002	SE	100	51	S4	M	01.00	04.00
003	SE	302	51	S4	S	01.00	04.00
004	SE	302	52	S4	T	08.00	11.00
005	SE	302	53	S4	U	07.00	10.00
006	SE	302	54	S4	U	02.00	05.00
007	SE	301	01	S1	SMW	07.00	08.00
008	SE	302	01	S1	SMW	03.00	04.00
009	SE	302	02	S1	SMW	09.00	10.00
010	SE	303	02	S1	SMW	10.00	11.00
011	SE	402	01	S3	UT	10.00	11.15
012	SE	303	52	S4	M	01.00	04.00
013	SE	320	01	S1	SMW	02.00	03.00
014	SE	325	02	S1	SMW	03.00	04.00
015	SE	405	01	S2	SM	08.00	09.00
016	SE	443	01	S2	UT	08.00	09.00
017	SE	443	51	S4	U	09.00	12.00
018	SE	207	02	S2	UT	02.00	03.00
019	SE	311	01	S2	SM	01.00	02.00
020	SE	207	53	S4	M	02.00	05.00
021	SE	302	03	S1	SMW	01.00	02.00
022	SE	302	04	S1	SMW	08.00	09.00
023	SE	201	01	S2	UT	09.00	10.00
024	SE	201	02	S2	SM	11.00	12.00
025	SE	311	51	S4	S	07.00	10.00
026	SE	311	52	S4	M	08.00	11.00
027	SE	405	02	S2	UT	07.00	08.00
028	SE	320	02	S3	SM	07.00	08.15
029	SE	100	03	S2	SM	01.00	02.00
030	SE	100	53	S4	U	01.00	04.00
031	SE	405	51	S4	S	09.00	12.00
032	SE	405	52	S4	T	09.00	12.00
033	SE	465	01	S1	SMW	10.00	11.00
034	SE	402	02	S3	UT	07.00	08.15
035	SE	320	03	S3	UT	08.00	09.15
036	SE	448	01	S3	UT	03.00	04.15
037	SE	207	01	S2	UT	07.00	08.00
038	SE	432	01	S2	SM	03.00	04.00
039	SE	207	52	S4	M	09.00	12.00
040	SE	303	01	S1	SMW	11.00	12.00
041	SE	325	01	S1	SMW	07.00	08.00
042	SE	303	51	S4	M	02.00	05.00
043	SE	205	01	S2	UT	11.00	12.00
044	SE	305	01	S2	SM	02.00	03.00
045	SE	205	51	S4	T	07.00	10.00
046	SE	305	S4	51	T	01.00	04.00
047	SE	461	S2	01	SM	11.00	12.00
048	SE	301	S1	08	SMW	07.00	08.00
049	SE	461	S4	51	T	02.00	05.00
050	SE	301	S1	06	SMW	07.00	08.00
051	SE	301	S1	07	SMW	03.00	04.00
052	SE	100	S2	02	SM	02.00	03.00
053	SE	100	S4	52	U	02.00	05.00

054	SE	207	S4	51	T	02.00	05.00
055	SE	207	S4	54	T	09.00	12.00
056	SE	401	S4	51	U	01.00	04.00
057	SE	401	S4	52	M	09.00	12.00
058	SE	401	S4	53	S	02.00	05.00
059	SE	401	S4	54	U	08.00	11.00
060	SE	205	S2	02	SM	03.00	04.00
061	SE	205	S4	52	S	09.00	12.00
062	SE	401	S2	02	SM	07.00	08.00
063	SE	301	S1	02	SMW	11.00	12.00
064	SE	301	S1	04	SMW	07.00	08.00
065	SE	315	S3	01	UT	02.00	03.15
066	SE	301	S1	03	SMW	07.00	08.00
067	SE	301	S1	09	SMW	03.00	04.00
068	SE	401	S2	01	UT	03.00	04.00
069	SE	301	S1	05	SMW	11.00	12.00
070	ICS	201	S1	05	SMW	07.00	08.00
071	ICS	201	S1	07	SMW	03.00	04.00
072	ICS	201	S4	54	U	01.00	04.00
073	ICS	201	S4	59	U	09.00	12.00
074	ICS	381	S1	01	SMW	07.00	08.00
075	ICS	413	S1	01	SMW	03.00	04.00
076	ICS	201	S1	06	SMW	07.00	08.00
077	ICS	201	S1	09	SMW	03.00	04.00
078	ICS	201	S4	52	U	01.00	04.00
079	ICS	201	S4	60	U	09.00	12.00
080	ICS	353	S1	03	SMW	07.00	08.00
081	ICS	101	S2	04	UT	07.00	08.00
082	ICS	411	S2	01	UT	09.00	10.00
083	ICS	411	S4	51	M	09.00	12.00
084	ICS	434	S1	01	SMW	02.00	03.00
085	ICS	252	S1	02	SMW	07.00	08.00
086	ICS	353	S1	02	SMW	03.00	04.00
087	ICS	101	S2	05	UT	08.00	09.00
088	ICS	101	S2	09	SM	03.00	04.00
089	ICS	101	S2	11	SM	02.00	03.00
090	ICS	201	S1	03	SMW	07.00	08.00
091	ICS	313	03	S1	SMW	03.00	04.00
092	ICS	334	52	S4	S	01.00	04.00
093	ICS	334	53	S4	S	09.00	12.00
094	ICS	102	07	S2	UT	10.00	11.00
095	ICS	102	51	S4	T	02.00	05.00
096	ICS	102	53	S4	M	09.00	12.00
097	ICS	102	56	S4	U	02.00	05.00
098	ICS	202	03	S1	SMW	07.00	08.00
099	ICS	432	01	S1	SMW	03.00	04.00
100	ICS	101	51	S4	S	01.00	04.00
101	ICS	101	52	S4	S	09.00	12.00
102	ICS	101	53	S4	U	09.00	12.00
103	ICS	201	57	S4	M	09.00	12.00
104	ICS	101	01	S2	SM	08.00	09.00
105	ICS	101	02	S2	SM	03.00	04.00
106	ICS	201	02	S1	SMW	07.00	08.00

Table 6.1: Section timings produced by the integer linear program   Cont...

#	Dept	Course	Sec	Type	Days	Start	End
107	ICS	201	04	S1	SMW	03.00	04.00
108	ICS	201	53	S4	U	01.00	04.00
109	ICS	201	58	S4	U	09.00	12.00
110	ICS	102	02	S2	SM	08.00	09.00
111	ICS	102	52	S4	T	02.00	05.00
112	ICS	102	54	S4	T	07.00	10.00
113	ICS	102	55	S4	U	02.00	05.00
114	ICS	202	01	S1	SMW	09.00	10.00
115	ICS	202	04	S1	SMW	02.00	03.00
116	ICS	252	03	S1	SMW	07.00	08.00
117	ICS	252	01	S1	SMW	07.00	08.00
118	ICS	353	01	S1	SMW	03.00	04.00
119	ICS	102	03	S2	UT	08.00	09.00
120	ICS	102	08	S2	SM	03.00	04.00
121	ICS	251	01	S1	SMW	10.00	11.00
122	ICS	251	02	S1	SMW	02.00	03.00
123	ICS	102	05	S2	UT	10.00	11.00
124	ICS	102	06	S2	SM	02.00	03.00
125	ICS	102	59	S4	M	09.00	12.00
126	ICS	102	60	S4	U	02.00	05.00
127	ICS	334	01	S1	SMW	07.00	08.00
128	ICS	102	01	S2	UT	10.00	11.00
129	ICS	102	04	S2	SM	02.00	03.00
130	ICS	413	51	S4	M	09.00	12.00
131	ICS	413	52	S4	U	02.00	05.00
132	ICS	102	57	S4	S	07.00	10.00
133	ICS	102	58	S4	T	02.00	05.00
134	ICS	201	01	S1	SMW	10.00	11.00
135	ICS	201	08	S1	SMW	11.00	12.00
136	ICS	202	02	S1	SMW	03.00	04.00
137	ICS	232	01	S1	SMW	02.00	03.00
138	ICS	232	51	S4	U	09.00	12.00
139	ICS	232	52	S4	T	09.00	12.00
140	ICS	354	01	S1	SMW	07.00	08.00
141	ICS	412	01	S3	UT	07.00	08.15
142	ICS	431	03	S1	SMW	03.00	04.00
143	ICS	434	02	S1	SMW	10.00	11.00
144	ICS	334	51	S4	U	01.00	04.00
145	ICS	101	03	S2	SM	10.00	11.00
146	ICS	101	55	S4	U	02.00	05.00
147	ICS	201	51	S4	S	01.00	04.00
148	ICS	201	55	S4	S	09.00	12.00
149	ICS	201	56	S4	U	09.00	12.00
150	ICS	201	61	S4	M	09.00	12.00
151	ICS	232	02	S1	SMW	07.00	08.00
152	ICS	251	03	S1	SMW	07.00	08.00
153	ICS	252	04	S1	SMW	07.00	08.00
154	ICS	313	01	S1	SMW	07.00	08.00
155	ICS	313	02	S1	SMW	03.00	04.00
156	ICS	334	02	S1	SMW	07.00	08.00
157	ICS	334	03	S1	SMW	03.00	04.00
158	ICS	353	04	S1	SMW	07.00	08.00
159	ICS	431	51	S4	S	01.00	04.00
160	ICS	431	52	S4	S	09.00	12.00
161	ICS	431	53	S4	U	09.00	12.00
162	ICS	432	51	S4	S	01.00	04.00
163	ICS	432	52	S4	S	09.00	12.00
164	ICS	101	54	S4	S	01.00	04.00
165	ICS	101	59	S4	S	09.00	12.00
166	ICS	101	60	S4	S	01.00	04.00
167	ICS	101	61	S4	S	09.00	12.00
168	ICS	101	63	S4	S	01.00	04.00
169	ICS	101	66	S4	S	09.00	12.00
170	ICS	101	67	S4	S	01.00	04.00
171	ICS	101	68	S4	S	09.00	12.00
172	ICS	431	01	S1	SMW	07.00	08.00
173	ICS	431	02	S1	SMW	03.00	04.00
174	ICS	490	01	S3	UT	07.00	08.15
175	ICS	101	08	S2	UT	07.00	08.00
176	ICS	101	10	S2	SM	03.00	04.00
177	COE	308	02	S3	UT	07.00	08.15
178	COE	308	01	S3	SM	07.00	08.15
179	COE	390	01	S2	UT	03.00	04.00
180	COE	200	54	S4	S	09.00	12.00
181	COE	305	03	S1	SMW	11.00	12.00
182	COE	484	01	S1	SMW	07.00	08.00
183	COE	200	11	S1	SMW	10.00	11.00
184	COE	442	02	S1	SMW	11.00	12.00
185	COE	442	04	S1	SMW	01.00	02.00
186	COE	305	02	S1	SMW	03.00	04.00
187	COE	200	52	S4	M	07.00	10.00
188	COE	360	02	S1	SMW	02.00	03.00
189	COE	360	03	S1	SMW	08.00	09.00
190	COE	449	01	S1	SMW	10.00	11.00
191	COE	200	51	S4	S	07.00	10.00
192	COE	305	51	S4	U	09.00	12.00
193	COE	305	52	S4	T	02.00	05.00
194	COE	305	53	S4	M	09.00	12.00
195	COE	200	56	S4	M	02.00	05.00
196	COE	342	01	S1	SMW	07.00	08.00
197	COE	441	01	S1	SMW	03.00	04.00
198	COE	205	03	S1	SMW	02.00	03.00
199	COE	205	04	S1	SMW	09.00	10.00
200	COE	200	55	S4	T	07.00	10.00
201	COE	442	51	S4	M	01.00	04.00
202	COE	442	52	S4	S	02.00	05.00
203	COE	442	53	S4	U	08.00	11.00
204	COE	442	54	S4	U	02.00	05.00
205	COE	200	02	S1	SMW	01.00	02.00
206	COE	200	05	S1	SMW	03.00	04.00
207	COE	390	02	S2	UT	08.00	09.00
208	COE	422	01	S4	M	02.00	05.00
209	COE	205	51	S4	T	09.00	12.00
210	COE	205	52	S4	S	01.00	04.00
211	COE	205	53	S4	U	08.00	11.00
212	COE	205	54	S4	U	01.00	04.00

Table 6.1: Section timings produced by the integer linear program   Cont...

213	COE	205	02	S1	SMW	08.00	09.00
214	COE	442	03	S1	SMW	09.00	10.00
215	COE	485	01	S1	SMW	02.00	03.00
216	COE	200	12	S1	SMW	02.00	03.00
217	COE	200	57	S4	U	07.00	10.00
218	COE	200	59	S4	S	08.00	11.00
219	COE	400	02	S2	UT	10.00	11.00
220	COE	400	02	S4	T	01.00	04.00
221	COE	200	03	S1	SMW	09.00	10.00
222	COE	200	07	S1	SMW	11.00	12.00
223	COE	485	51	S4	U	07.00	10.00
224	COE	200	60	S4	T	01.00	04.00
225	COE	200	01	S1	SMW	07.00	08.00
226	COE	400	01	S2	UT	01.00	02.00
227	COE	400	01	S4	T	09.00	12.00
228	COE	200	09	S1	SMW	08.00	09.00
229	COE	200	61	S4	T	08.00	11.00
230	COE	342	02	S1	SMW	01.00	02.00
231	COE	353	01	S1	SMW	10.00	11.00
232	ME	206	03	S1	SMW	07.00	08.00
233	ME	206	05	S1	SMW	03.00	04.00
234	ME	206	53	S4	U	07.00	10.00
235	SE	322	03	S1	SMW	07.00	08.00
236	SE	322	05	S1	SMW	03.00	04.00
237	SE	322	53	S4	U	07.00	10.00
238	ME	306	53	S4	S	01.00	04.00
239	ME	306	56	S4	S	09.00	12.00
240	ME	308	52	S4	U	09.00	12.00
241	ME	308	57	S4	M	09.00	12.00
242	ME	413	56	S4	S	07.00	10.00
243	ME	203	04	S1	SMW	07.00	08.00
244	ME	311	04	S1	SMW	03.00	04.00
245	ME	215	05	S3	SM	10.00	11.15
246	ME	472	02	S1	SMW	03.00	04.00
247	ME	206	54	S4	S	07.00	10.00
248	SE	322	54	S4	S	07.00	10.00
249	ME	206	51	S4	S	07.00	10.00
250	ME	210	01	S2	UT	10.00	11.00
251	ME	210	01	S4	T	02.00	05.00
252	SE	322	51	S4	S	07.00	10.00
253	AE	333	01	S1	SMW	07.00	08.00
254	ME	203	08	S1	SMW	03.00	04.00
255	ME	433	01	S1	SMW	02.00	03.00
256	ME	309	02	S1	SMW	08.00	09.00
257	AE	220	01	S1	SMW	07.00	08.00
258	AE	426	01	S1	SMW	11.00	12.00
259	ME	320	01	S1	SMW	03.00	04.00
260	ME	426	01	S1	SMW	02.00	03.00
261	ME	435	51	S4	S	07.00	10.00
262	ME	309	01	S1	SMW	07.00	08.00
263	ME	309	05	S1	SMW	11.00	12.00
264	ME	205	04	S2	UT	09.00	10.00
265	ME	215	02	S3	SM	03.00	04.15
266	ME	201	03	S1	SMW	10.00	11.00
267	ME	201	04	S4	SMW	11.00	12.00
268	ME	203	10	S1	SMW	10.00	11.00
269	ME	311	02	S1	SMW	11.00	12.00
270	ME	308	51	S4	M	01.00	04.00
271	ME	403	56	S4	S	09.00	12.00
272	ME	413	53	S4	U	09.00	12.00
273	ME	413	54	S4	M	09.00	12.00
274	ME	413	58	S4	T	09.00	12.00
275	ME	206	52	S4	M	01.00	04.00
276	ME	206	55	S4	S	09.00	12.00
277	ME	206	56	S4	U	09.00	12.00
278	ME	206	57	S4	M	09.00	12.00
279	SE	322	52	S4	M	01.00	04.00
280	SE	322	55	S4	S	09.00	12.00
281	SE	322	56	S4	U	09.00	12.00
282	SE	322	57	S4	M	09.00	12.00
283	ME	482	52	S4	T	09.00	12.00
284	ME	315	05	S1	SMW	10.00	11.00
285	ME	440	01	S1	SMW	11.00	12.00
286	ME	307	02	S1	SMW	10.00	11.00
287	ME	307	03	S1	SMW	11.00	12.00
288	ME	308	05	S1	SMW	01.00	02.00
289	ME	413	55	S4	T	07.00	10.00
290	ME	311	03	S1	SMW	10.00	11.00
291	ME	311	05	S1	SMW	11.00	12.00
292	ME	438	01	S3	UT	10.00	11.15
293	ME	403	51	S4	S	01.00	04.00
294	ME	413	51	S4	S	09.00	12.00
295	ME	413	52	S4	U	09.00	12.00
296	ME	413	57	S4	M	09.00	12.00
297	ME	204	04	S1	SMW	03.00	04.00
298	ME	307	01	S1	SMW	03.00	04.00
299	SE	322	02	S1	SMW	08.00	09.00
300	ME	204	01	S1	SMW	08.00	09.00
301	ME	436	03	S1	SMW	11.00	12.00
302	ME	204	03	S1	SMW	10.00	11.00
303	ME	439	01	S1	SMW	11.00	12.00
304	ME	413	02	S2	UT	08.00	09.00
305	ME	413	05	S2	SM	03.00	04.00
306	ME	482	01	S2	SM	02.00	03.00
307	ME	311	07	S1	SMW	03.00	04.00
308	ME	215	53	S4	S	01.00	04.00
309	ME	316	01	S4	S	09.00	12.00
310	ME	316	05	S4	U	09.00	12.00
311	ME	215	54	S4	S	01.00	04.00
312	ME	316	06	S4	S	09.00	12.00
313	ME	316	07	S4	U	09.00	12.00
314	ME	201	01	S1	SMW	03.00	04.00
315	ME	201	02	S1	SMW	11.00	12.00
316	ME	413	01	S2	UT	07.00	08.00
317	ME	316	02	S4	S	01.00	04.00
318	ME	316	04	S4	S	09.00	12.00

Table 6.1: Section timings produced by the integer linear program   Cont...

319	ME	438	52	S4	U	09.00	12.00		372	ME	315	06	S1	SMW	01.00	02.00
320	ME	205	54	S4	S	01.00	04.00		373	ME	206	01	S1	SMW	08.00	09.00
321	ME	215	52	S4	S	09.00	12.00		374	ME	206	04	S1	SMW	11.00	12.00
322	ME	215	58	S4	U	09.00	12.00		375	ME	471	01	S1	SMW	01.00	02.00
323	ME	215	59	S4	M	09.00	12.00		376	SE	322	01	S1	SMW	08.00	09.00
324	ME	215	07	S3	UT	07.00	08.15		377	SE	322	04	S1	SMW	11.00	12.00
325	ME	206	02	S1	SMW	08.00	09.00		378	ME	309	03	S1	SMW	07.00	08.00
326	ME	307	04	S1	SMW	11.00	12.00		379	ME	403	04	S1	SMW	11.00	12.00
327	AE	328	01	S1	SMW	09.00	10.00		380	ME	315	01	S1	SMW	03.00	04.00
328	ME	413	03	S2	UT	07.00	08.00		381	ME	205	51	S4	T	07.00	10.00
329	ME	413	04	S2	SM	03.00	04.00		382	ME	205	53	S4	S	09.00	12.00
330	ME	428	01	S1	SMW	10.00	11.00		383	ME	205	55	S4	U	09.00	12.00
331	ME	203	06	S1	SMW	10.00	11.00		384	ME	215	56	S4	M	09.00	12.00
332	ME	203	13	S1	SMW	11.00	12.00		385	AE	325	01	S1	SMW	07.00	08.00
333	AE	420	01	S4	S	01.00	04.00		386	ME	204	05	S1	SMW	11.00	12.00
334	ME	306	51	S4	S	09.00	12.00		387	ME	425	01	S1	SMW	01.00	02.00
335	ME	306	52	S4	U	09.00	12.00		388	ME	210	02	S2	UT	09.00	10.00
336	ME	306	55	S4	M	09.00	12.00		389	ME	210	02	S4	M	09.00	12.00
337	ME	308	01	S1	SMW	10.00	11.00		390	ME	204	02	S1	SMW	07.00	08.00
338	ME	308	02	S1	SMW	11.00	12.00		391	ME	437	01	S1	SMW	11.00	12.00
339	ME	308	03	S1	SMW	01.00	02.00		392	GEOP	402	01	S3	UT	10.00	11.15
340	ME	215	03	S3	SM	10.00	11.15		393	GEOP	402	51	S4	S	02.00	05.00
341	ME	215	04	S3	SM	03.00	04.15		394	GEOL	305	01	S2	UT	08.00	09.00
342	AE	411	01	S4	T	07.00	10.00		395	GEOL	305	51	S4	S	01.00	04.00
343	AE	412	01	S4	S	09.00	12.00		396	GEOL	350	01	S3	UT	01.00	02.15
344	ME	203	09	S1	SMW	03.00	04.00		397	GEOL	350	51	S4	S	08.00	11.00
345	ME	205	52	S4	M	07.00	10.00		398	GEOL	409	01	S3	SM	01.00	02.15
346	ME	316	03	S4	S	09.00	12.00		399	GEOP	315	01	S1	SMW	08.00	09.00
347	ME	316	08	S4	U	09.00	12.00		400	GEOP	315	51	S4	T	01.00	04.00
348	ME	210	03	S2	UT	10.00	11.00		401	GEOP	405	01	S3	SM	09.30	10.45
349	ME	210	03	S4	M	09.00	12.00		402	GEOL	402	01	S3	UT	10.30	11.45
350	ME	210	04	S2	SM	02.00	03.00		403	GEOL	402	51	S4	M	02.00	05.00
351	ME	210	04	S4	U	02.00	05.00		404	GEOL	201	01	S2	SM	01.00	02.00
352	ME	205	02	S2	UT	07.00	08.00		405	GEOL	201	51	S4	T	02.00	05.00
353	ME	205	03	S2	SM	03.00	04.00		406	GEOL	203	01	S2	UT	11.00	12.00
354	ME	308	53	S4	S	01.00	04.00		407	GEOL	203	51	S4	T	08.00	11.00
355	ME	308	54	S4	S	09.00	12.00		408	GEOL	415	01	S1	SMW	07.00	08.00
356	ME	308	55	S4	U	09.00	12.00		409	GEOL	311	01	S2	UT	07.00	08.00
357	ME	308	56	S4	M	09.00	12.00		410	GEOL	311	51	S4	S	07.00	10.00
358	ME	206	58	S4	S	07.00	10.00		411	GEOP	430	01	S3	UT	07.00	08.15
359	SE	322	58	S4	S	07.00	10.00		412	GEOP	430	51	S4	T	02.00	05.00
360	ME	315	03	S1	SMW	09.00	10.00		413	GEOP	455	01	S3	SM	03.00	04.15
361	ME	315	04	S1	SMW	11.00	12.00		414	GEOL	454	01	S1	SMW	01.00	02.00
362	ME	423	01	S1	SMW	01.00	02.00		415	GEOL	454	51	S3	UT	02.00	03.15
363	ME	203	02	S1	SMW	09.00	10.00		416	GEOP	202	01	S1	SMW	08.00	09.00
364	ME	435	01	S2	UT	07.00	08.00		417	GEOP	450	01	S3	SM	10.30	11.45
365	ME	306	04	S2	UT	07.00	08.00		418	GEOL	341	01	S1	SMW	03.00	04.00
366	ME	462	01	S1	SMW	03.00	04.00		419	GEOL	446	01	S1	SMW	02.00	03.00
367	ME	306	01	S2	UT	09.00	10.00		420	ACCT	201	01	S2	SM	09.00	10.00
368	ME	306	03	S2	SM	03.00	04.00		421	ACCT	201	51	S4	T	08.00	11.00
369	ME	463	01	S1	SMW	11.00	12.00		422	ACCT	201	02	S2	SM	10.00	11.00
370	ME	203	01	S1	SMW	08.00	09.00		423	ACCT	201	52	S4	S	02.00	05.00
371	ME	203	12	S1	SMW	11.00	12.00		424	ACCT	201	05	S2	SM	01.00	02.00

Table 6.1: Section timings produced by the integer linear program Cont...

531	ECON	101	01	S1	SMW	01.00	02.00		539	FIN	420	01	S3	SM	10.00	11.15
532	ECON	101	02	S1	SMW	10.00	11.00		540	FIN	430	01	S3	UT	03.00	04.15
533	ECON	403	03	S3	SM	01.00	02.15		541	FIN	301	01	S3	UT	01.00	02.15
534	ECON	403	04	S3	UT	07.30	08.45		542	FIN	301	02	S3	UT	08.30	09.45
535	ECON	306	01	S1	SMW	07.00	08.00		543	FIN	421	01	S3	SM	03.00	04.15
536	ECON	306	02	S1	SMW	03.00	04.00		544	FIN	302	01	S3	UT	02.00	03.15
537	ECON	415	01	S1	SMW	02.00	03.00		545	FIN	301	03	S3	UT	10.30	11.45
538	FIN	410	01	S3	UT	07.00	08.15									

To verify the schedule, we consider a faculty member Mr. AKHTAR S. The teaching schedule for this faculty is shown as in Table 6.2.

Table 6.2: Teaching schedule for a faculty member

| Time/Day	Saturday	Sunday	Monday	Tuesday
07.00-08.00		005 (SE-302-53)		
08.00-09.00		005 (SE-302-53)		004 (SE-302-52)
09.00-10.00		005 (SE-302-53)		004 (SE-302-52)
10.00-11.00	001 (SE-100-01)		001 (SE-100-01)	004 (SE-302-52)
11.00-12.00				
01.00-02.00			002 (SE-100-51)	003 (SE-302-51)
02.00-03.00		006 (SE-302-54)	002 (SE-100-51)	003 (SE-302-51)
03.00-04.00		006 (SE-302-54)	002 (SE-100-51)	003 (SE-302-51)
04.00-05.00		006 (SE-302-54)		

So we see that the faculty member has no conflicts.
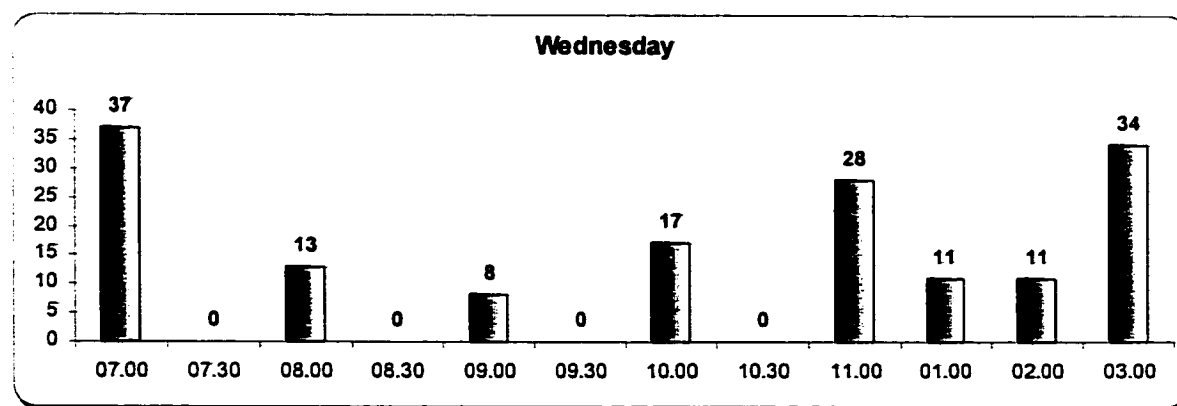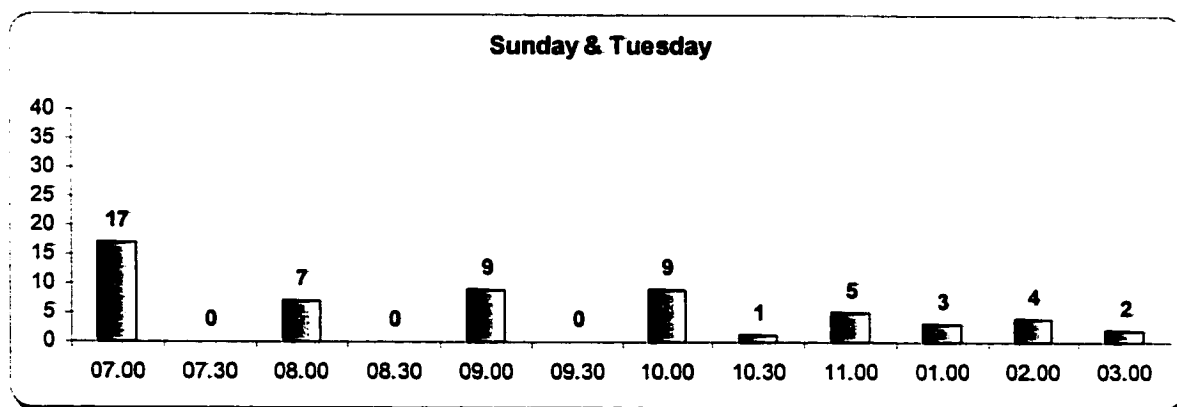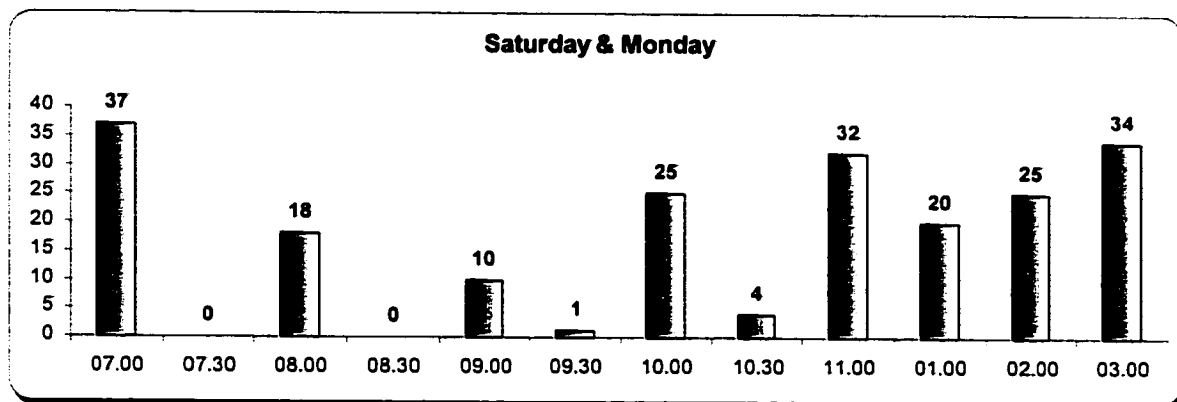
Figure 6.1: Number of small rooms used during the week
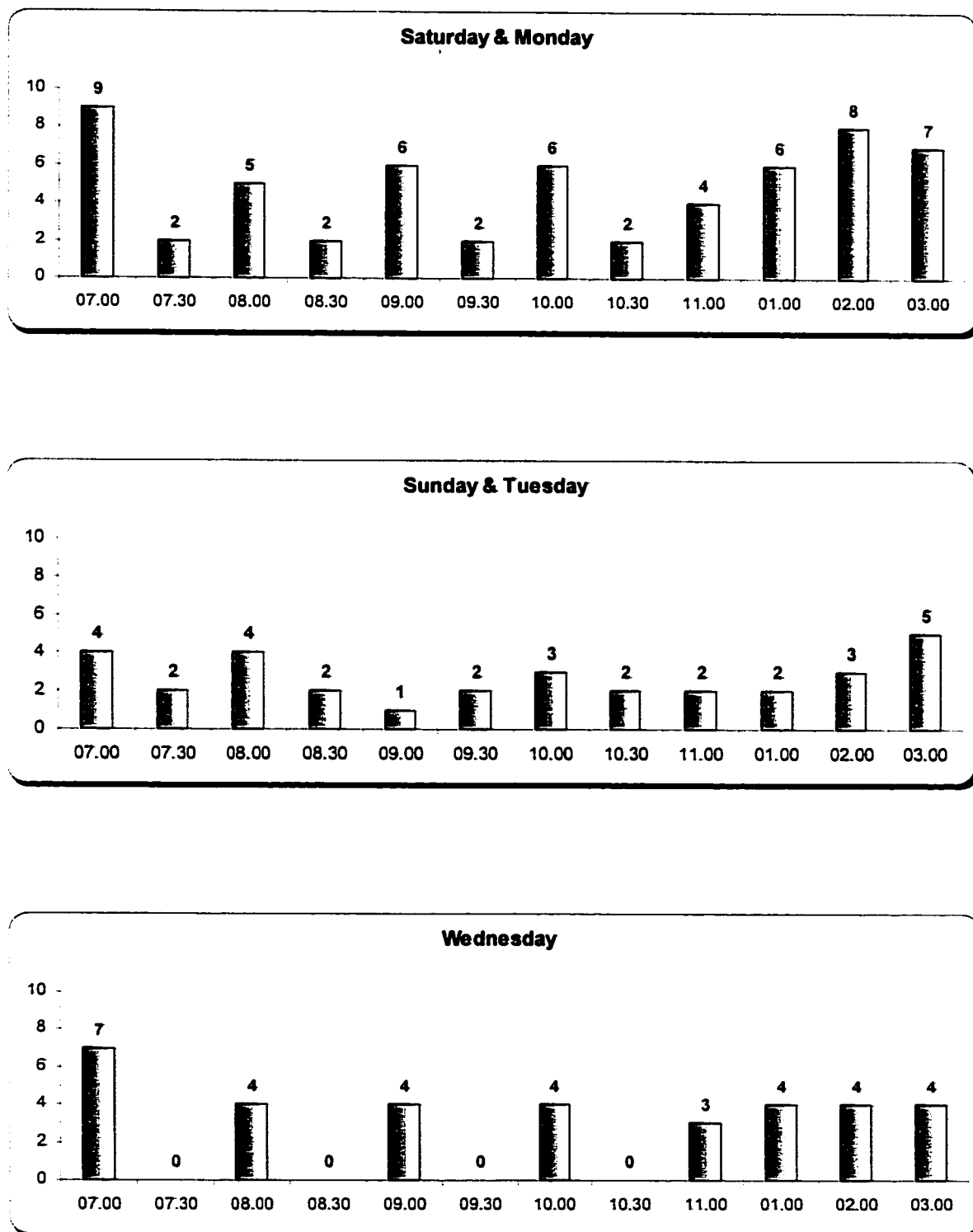
Figure 6.2: Number of large rooms used during the week

6.2 Model Extension I

The integer program developed so far has no objective function. In this section we extend the model by attempting to take into account the convenience of the students who in general do not prefer early and late periods, the model was extended by adding such constraints which will either totally avoid these periods or will minimize the allotment of sections to these periods.

The set of periods considered as early and late periods are tabulated in Table 6.3

Table 6.3: Early and Late Periods

	Early Periods				Late Periods			
S1	001	S, M, W	07.00	08.00	008	S, M, W	03.00	04.00
S2	009	UT	07.00	08.00	016	UT	03.00	04.00
	017	SM	07.00	08.00	024	SM	03.00	04.00
S3	025	UT	07.00	08.15	032	UT	03.00	04.15
	033	UT	07.30	08.45	044	SM	03.00	04.15
	037	SM	07.00	08.15				
	045	SM	07.30	08.45				

To get a feasible solution for all the periods considered together, the model was solved in different modules considering each combination of each early and late periods with its respective period-set (S1, S2, S3). So we have the following 12 cases

Case 1: Minimizing early S1 periods

Case 2: Minimizing early S2 periods

Case 3: Minimizing early S3 periods

Case 4: Minimizing early S1, S2, S3 periods

Case 5: Minimizing late S1 periods

Case 6: Minimizing late S2 periods

Case 7: Minimizing late S3 periods

Case 8: Minimizing late S1, S2, S3 periods

Case 9: Minimizing both early and late S1 periods

Case 10: Minimizing both early and late S2 periods

Case 11: Minimizing both early and late S3 periods

Case 12: Minimizing both early and late S1, S2, S3 periods

6.2.1 Objective Function and Constraints Added

Let us consider Case 1. As mentioned before the original constraints are modified to consider the students' non-preference of the early and late periods. We added slacks to each of the room constraints. This slack represents the number of unused rooms in a given time period.

Let S_{0j} be the slack for the small classroom constraints at period P and S_{1j} be the slack for the large classroom constraints at period j where $01 \leq j \leq 48$.

Then we constructed the following integer linear program

Maximize C;

Subject to $\quad S_{001} \geq SR;$ $\qquad\qquad\qquad$ (1)

$\qquad\qquad S_{001} \geq LR;$ $\qquad\qquad\qquad$ (2)

$\qquad\qquad S_{0j} \geq C;$ $\qquad j = 2, 48$ $\qquad$ (3)

$\qquad\qquad S_{1j} \geq C;$ $\qquad j = 2, 48$ $\qquad$ (4)

$\qquad\qquad x \in X$

where X is the set of constraints developed and mentioned in Chapter 5 after adding slacks to the room constraints.

Initially we started with SR = 37 and LR = 29. Since there are 37 small rooms, constraint (1) implies that no small rooms are used. Similarly for constraint (2).

Constraints (3) and (4) attempt to increase the number of unused small and large rooms during the other time periods. This may result in even distribution of the number of used rooms during the week. If the problem is infeasible then the values of SR and LR were decreased by 1. This process was repeated until values of SR and LR were reached where the model yielded a feasible solution. SR = 34 and LR = 26 resulted in a feasible solution for the problem in hand.

Similarly, Cases 2 to 11 were solved using the time periods shown in Table 6.3. Case 12 was solved using the values of SR and LR obtained from the earlier cases. The integer linear program solved is

Maximize C;

Subject to

$$
\begin{array}{llllll}
S_{001} \geq 34; & S_{101} \geq 26; & S_{008} \geq 35; & S_{108} \geq 26; & S_{001} \geq 36; & S_{001} \geq 29; \\[2mm]
S_{016} \geq 36; & S_{116} \geq 29; & S_{017} \geq 36; & S_{117} \geq 29; & S_{024} \geq 36; & S_{124} \geq 29; \\[2mm]
S_{001} \geq 36; & S_{001} \geq 29; & S_{001} \geq 37; & S_{001} \geq 29; & S_{001} \geq 37; & S_{133} \geq 29; \\[2mm]
S_{037} \geq 37; & S_{137} \geq 29; & S_{044} \geq 37; & S_{144} \geq 29; & S_{045} \geq 37; & S_{145} \geq 29;
\end{array}
\tag{5}
$$

$$
S_{0j}, S_{1j} \geq C \quad
\begin{cases}
01 \leq j \leq 48 \\[2mm]
j \neq 01,08,09,16,17,24,25,32,33,37,44,45
\end{cases}
$$
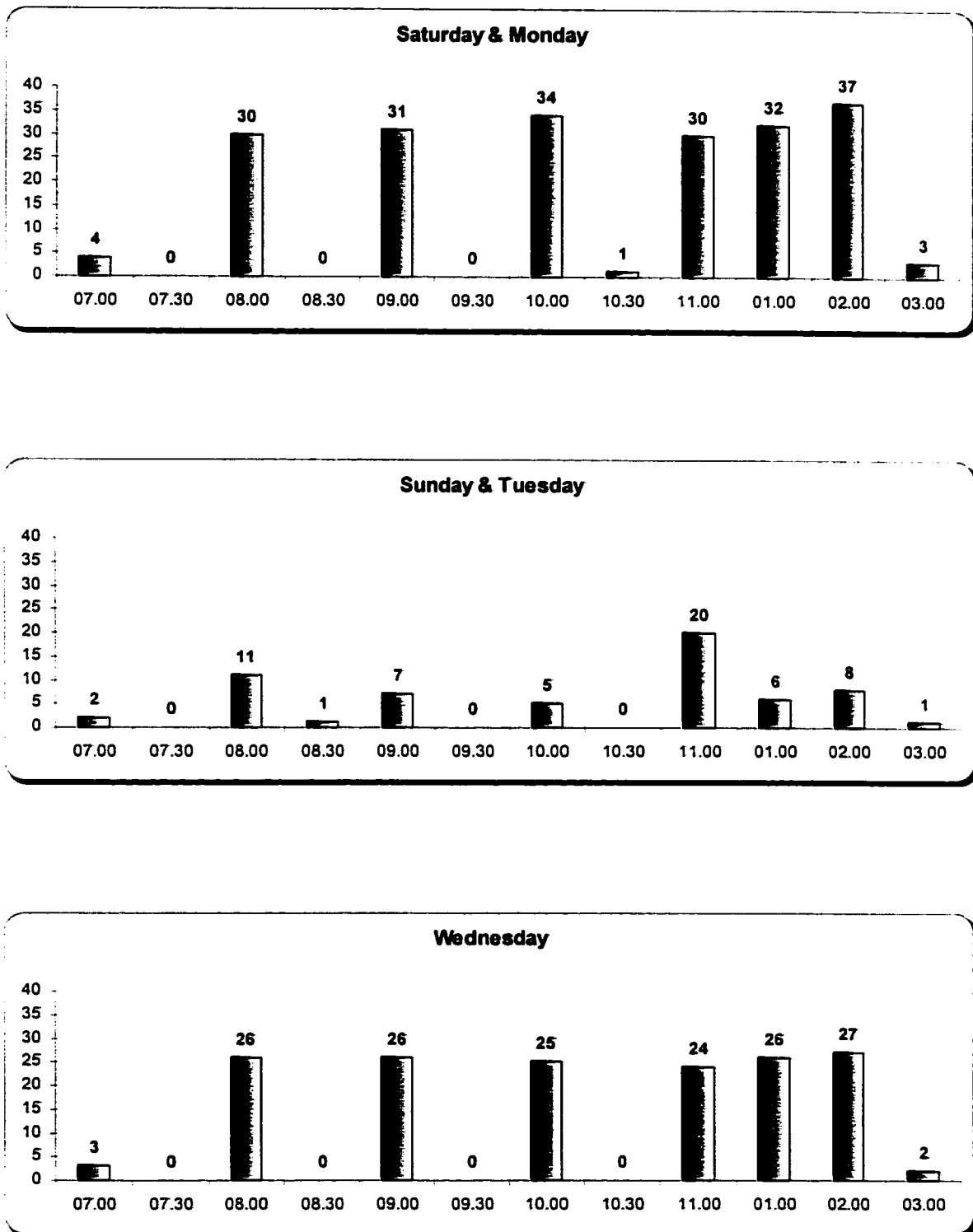
Figure 6.3: Number of small rooms used during the week (Extension I)
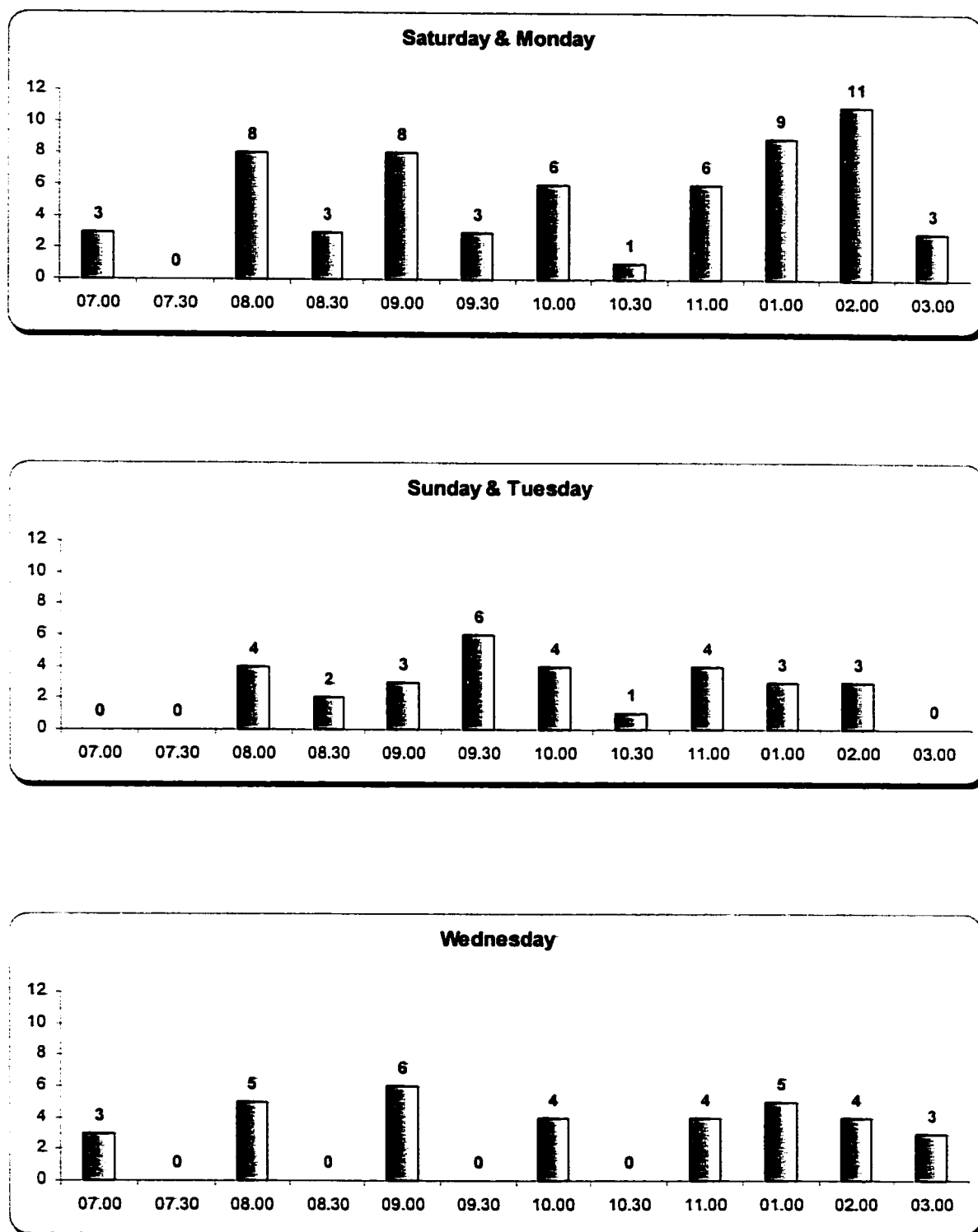
Figure 6.4: Number of large rooms used during the week (Extension I)

6.2.2 Comparison of the Original and Extended Model

The Figures 6.5 and 6.6 show a comparison of number of rooms used for both the original and the extended model. It is clearly evident that the desired objective of minimizing the allotment of sections to late and early periods is achieved by the extended model.
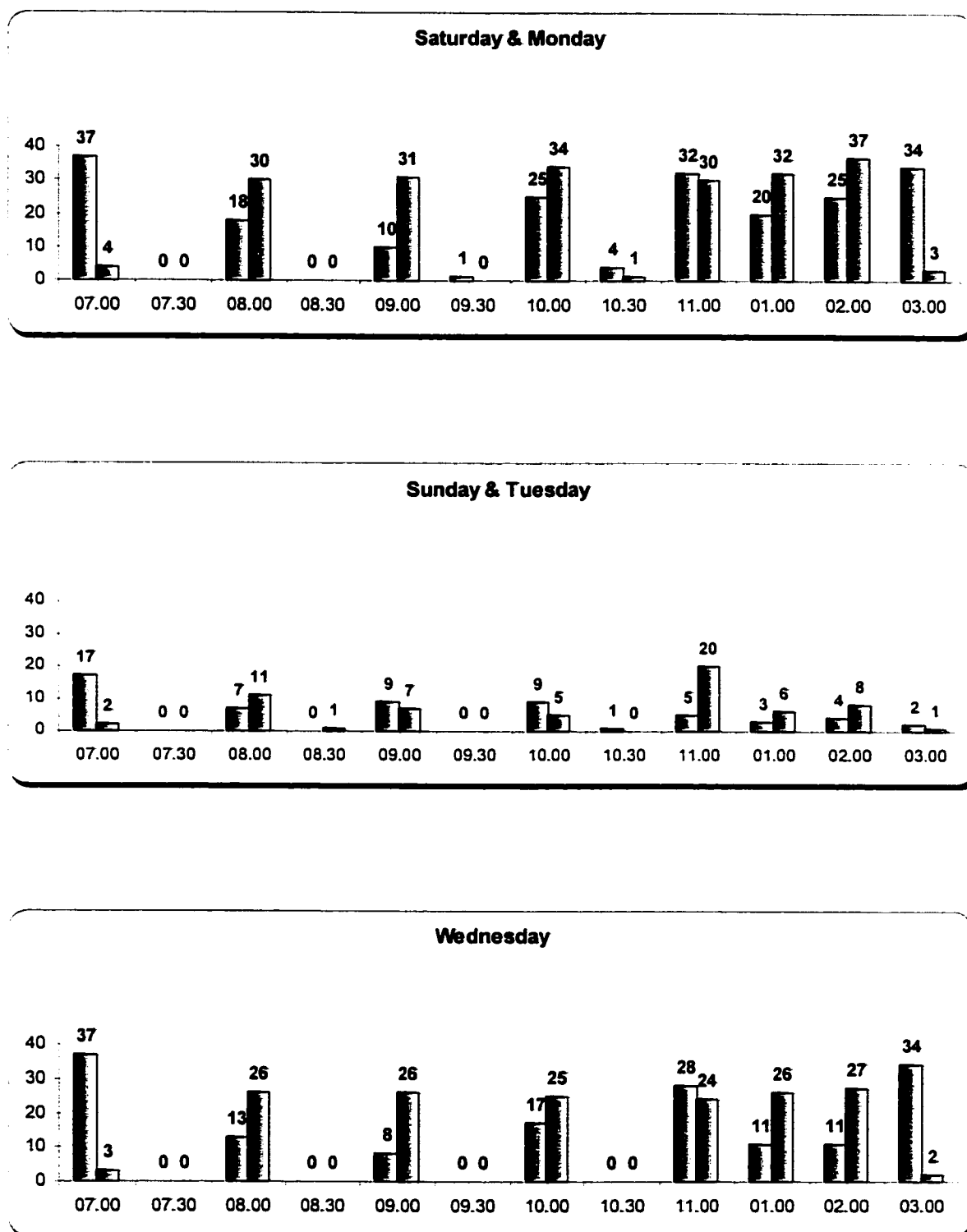
Figure 6.5: Number of small rooms used during the week

Comparison between Original and Extended Model
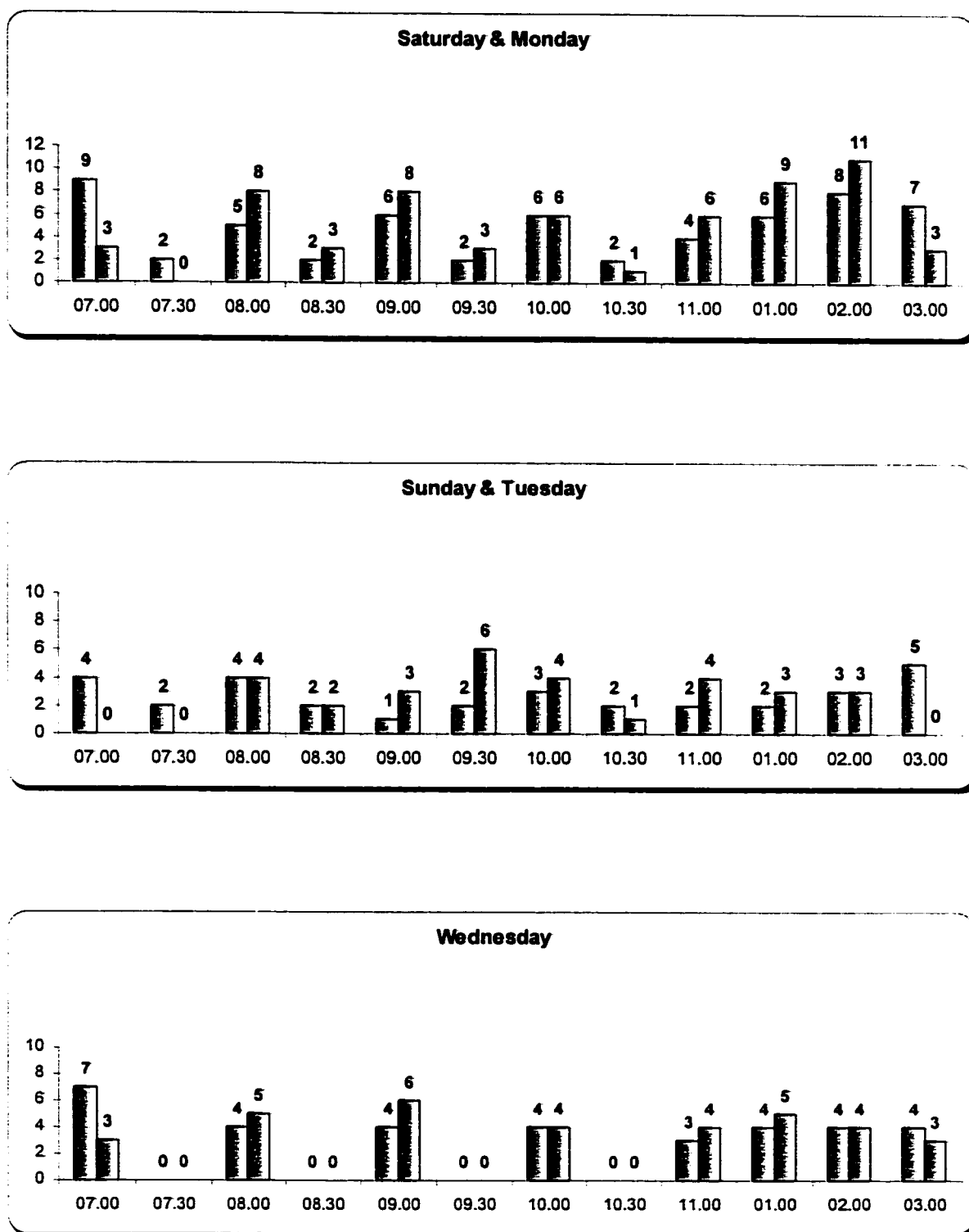
Figure 6.6: Number of large rooms used during the week
Comparison between Original and Extended Model

6.3 Model Extension II

Another extension of the model attempts to have an even distribution of the number of students attending classes over the hours of the day. This objective has two advantages. Firstly, the need for car parking spaces will be uniform from hour to hour and day to day. Secondly, the classroom building will be less crowded

6.3.1 Objective Function and Constraints Added

Let A_S and A_L be the average maximum enrollment for the small and large sections respectively, SR and LR be the number of small and large rooms respectively and S_{0j} and S_{1j} be the number of unused rooms (slacks) at period j, then the total number of students at any particular period j attending classes will be

$$(SR - S_{0j})*A_S + (LR - S_{1j})*A_L$$

and we set the objective function of the model as

Minimize C;

Subject to

$$(SR - S_{0j})*A_S + (LR - S_{1j})*A_L \leq C \qquad 01 \leq j \leq 48 \qquad (6)$$

$$x \in X \qquad \text{and} \qquad \text{constraint set } (5)$$

The constraints given by (6) can be simplified as follows

$$(A_S * S_{0j} + A_L * S_{1j}) + C \geq (A_S * SR + A_L * LR)$$

For our problem

$$A_S = 25.327, \quad A_L = 37.89011, \quad SR = 37, \quad LR = 29$$

and thus $\qquad A_S * SR + A_L * LR = 2035.912$

The integer linear program was solved using the above constraints along with the original constraints mentioned in chapter 3 for sections, faculty and room constraints after adding slacks. An optimal solution was not attained after 25,500 iterations. The best solution was C=810.06, *i.e*, the maximum number of students taking lectures in the classroom buildings at any time is ≤ 810.

6.4   Summary of the Thesis

The thesis presented here develops a model for getting a schedule for courses offered in a semester. The constraints for the problem are generated, namely the section constraints, faculty constraints, room constraints and section clusters constraints. The data for the problem was obtained from the Deanship of Admissions and Registration, KFUPM. The data included all the necessary details required for the problem. Here the course was combined with the faculty member and was called a section. In other words the courses are already assigned a faculty member. The problem was to assign these sections to a specific set of periods. Here the departments of the university were grouped according to the location of classroom buildings nearest to them. We had four groups and the group using buildings 22 and 24 was studied as a illustration for all the groups. This grouping operation reduced the huge task of assigning all sections offered in the university into a integer linear program of manageable size for each group.

The generation of the constraints was done by analyzing the data for the selected group into different tables for each of the set of constraints. The generation of the constraints was coded. After getting all the set of constraints they were combined and solved using LINGO which resulted in a feasible solution and the result was presented in a tabular format with the days and start and finish times of each section. The results have

been graphically illustrated in terms of usage of rooms during the week for both small and large classrooms. The model was extended in two ways. Firstly, the preferences of the students who do not prefer early and late time periods were considered and secondly almost even distribution of the number of students attending classes over the hours of the day have been achieved which had the advantage of making the need of car parking space uniform during the day and the classrooms being less crowded. These extensions have been described and results discussed.

6.5   Directions for Future Research

Only the preferences for the students like avoiding the early and late periods etc have been studied. But the preferences for the faculty have not been considered and can be incorporated in the model for future work. The assignment of labs to rooms had been neglected and can be taken into account by dividing the labs into two groups: ones that can be conducted in regular classrooms and the ones that have to be conducted in special rooms like computer labs, workshops etc. These ideas can be incorporated in the model and studied for future research.

Appendix

Codes Used to Generate the Constraints

A.1   Code 1 (Range) (Visual Basic)

```
Option Explicit

Private Sub Command1_Click()
Dim Hrs As String
Dim FileName As String
Dim HrRange(200) As String
Dim I As Integer
Dim SNo As Integer
  CommonDialog1.Action = 1
  FileName = CommonDialog1.FileName
  Open FileName For Input As #1
  Open FileName + ".xls" For Output As #2
  SNo = 0
  Do While Not EOF(1)
    SNo = SNo + 1
    Input #1, Hrs

  If (Hrs = "S2") Then
    Print #2, "0" + Chr(9) + Str(SNo);

    For I = 9 To 17
       Print #2, Chr(9) + Str(I);
    Next I
    Print #2, Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo);

    For I = 18 To 24
       Print #2, Chr(9) + Str(I);
    Next I
    Print #2, Chr(9) + "1000" + Chr(13) + Chr(10);

  End If

  If (Hrs = "S1") Then
    Print #2, "0" + Chr(9) + Str(SNo);

    For I = 1 To 8
```

```
        Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(9) + "1000" + Chr(13) + Chr(10);

   End If

   If (Hrs = "S3") Then
      Print #2, "0" + Chr(9) + Str(SNo);

      For I = 25 To 33
         Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo);

      For I = 34 To 42
         Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo);

      For I = 43 To 48
         Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(9) + "1000" + Chr(13) + Chr(10);

   End If

   If (Hrs = "S4") Then
      Print #2, "0" + Chr(9) + Str(SNo);

      For I = 49 To 57
         Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo);

      For I = 58 To 66
         Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo);

      For I = 67 To 68
         Print #2, Chr(9) + Str(I);
      Next I
      Print #2, Chr(9) + "1000" + Chr(13) + Chr(10);

   End If
  Loop
 End
End Sub
```

A.2   Code 2 (Constraint 1) (Visual Basic)

```vb
Option Explicit

Private Sub cmdReadFile_Click()
Dim FirstTwoDigits As Integer
Dim FileName As String
Dim InputFile As Integer
Dim OutputFile As Integer
Dim Temp As Integer
Dim az As String

    InputFile = FreeFile
    Open "E:\My Data\Raw\lat\VBProgs\VBProgsNew\Answer.txt" For Input As #InputFile

    While Not EOF(InputFile)
       Input #InputFile, Temp
       If (Temp = 0) Then
          az = az + Chr(13) + Chr(10)
          Input #InputFile, FirstTwoDigits
       ElseIf (Temp = 1000) Then
          az = az + "   = 1;"
       Else
          az = az + Chr(9) + "X" + _
          Format(FirstTwoDigits, "000") + Format(Temp, "000") + Chr(9) + "+"
       End If
    Wend
    Close InputFile

  OutputFile = FreeFile
  Open "E:\My Data\Raw\lat\VBProgs\VBProgsNew\AnswerFacEq.txt" For Output As #OutputFile
    Print #OutputFile, az
    Close OutputFile
    Unload Form1
End Sub
```

A.3   Code 3 (Constraints 2) (Visual Basic)

```vb
Option Explicit

Private Sub cmdReadFile_Click()
Dim FirstTwoDigits As Integer
Dim FileName As String
Dim InputFile As Integer
Dim OutputFile As Integer
Dim Temp As Integer
Dim az As String
    CommonDialog1.Action = 1
    FileName = CommonDialog1.FileName
    Open FileName For Input As #1
    Open FileName + ".xls" For Output As #2

    While Not EOF(1)
       Input #1, Temp
```

```vb
If (Temp = 0) Then
    az = az + Chr(13) + Chr(10)
    Input #1, FirstTwoDigits
ElseIf (Temp = 1000) Then
    az = az + "   = 1;"
Else
    az = az + Chr(9) + "X" + _
    Format(FirstTwoDigits, "000") + Format(Temp, "000") + Chr(9) + "+"
End If
Wend
Close 1

Print #2, az
Close 2
Unload Form1
End Sub
```

A.4   Code 4 (Conflict Sets) (Visual Basic)

```vb
Option Explicit

Private Sub cmdReadFile_Click()
Dim Hrs As String
Dim InputFile As Integer
Dim OutputFile As Integer
Dim SNo As Integer
Dim az As String

'Conflict Set 1
    InputFile = FreeFile
    Open "E:\My Data\Raw\lat\VBProgs\VBProgsNew\Latest.txt" For Input As InputFile

    SNo = 0
    Do While Not EOF(InputFile)
        SNo = SNo + 1
        Input #InputFile, Hrs

        If (Hrs = "S2") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "17"
        End If

        If (Hrs = "S1") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "1"
        End If

        If (Hrs = "S3") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "37" + _
        Chr(9) + "45"
        End If

        If (Hrs = "S4") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "49"
        End If
    Loop
```

```
        Close InputFile

'Conflict Set 2
    InputFile = FreeFile
    Open "E:\My Data\Raw\lat\VBProgs\VBProgsNew\Latest.txt" For Input As InputFile

    SNo = 0
    Do While Not EOF(InputFile)
        SNo = SNo + 1
        Input #InputFile, Hrs

        If (Hrs = "S2") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "18"
        End If

        If (Hrs = "S1") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "2"
        End If

        If (Hrs = "S3") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "37" + _
        Chr(9) + "38" + Chr(9) + "45"
        End If

        If (Hrs = "S4") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "49" + _
        Chr(9) + "50"
        End If
    Loop
    Close InputFile

. . . . . . . . . .
. . . . . . . . . .
. . . . . . . . . .
. . . . . . . . . .
. . . . . . . . . .

'Conflict Set 44
    InputFile = FreeFile
    Open "E:\My Data\Raw\lat\VBProgs\VBProgsNew\Latest.txt" For Input As InputFile

    SNo = 0
    Do While Not EOF(InputFile)
        SNo = SNo + 1
        Input #InputFile, Hrs

        If (Hrs = "S2") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "16"
        End If

        If (Hrs = "S1") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "99"
        End If

        If (Hrs = "S3") Then
        az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "31" + _
```

```
            Chr(9) + "32"
            End If


            If (Hrs = "S4") Then
            az = az + Chr(13) + Chr(10) + "0" + Chr(9) + Str(SNo) + Chr(9) + "67" + _
            Chr(9) + "68"
            End If
        Loop
        Close InputFile

        OutputFile = FreeFile
        Open "E:\My Data\Raw\lat\VBProgs\VBProgsNew\Answer.txt" For Output As OutputFile
        Print #OutputFile, az
        Close OutputFile
        Unload Form1
End Sub
```

A.5   Code 5 (Facstops) (Java)

```java
package azmathfacstops;

import java.io.*;
import java.util.*;

public class facStops {

  Vector answerString = new Vector();
  Object facstopsArray [];
  PrintStream fileOutput;

  public facStops() {
    try {
      fileOutput = new PrintStream(new FileOutputStream("FinFacEq.out"));
    } catch (FileNotFoundException fe) {}
    readAnswerFile();
    readFacStopsFile();
    makeConstraints();
    //for(int i=0; i<answerString.size(); i++)
      //fileOutput.println(answerString.elementAt(i));
  }

  public void readAnswerFile(){
    File outputFile = new File("AnswerFacEq.txt");
    BufferedReader br = null;
    try{
      br = new BufferedReader(new FileReader(outputFile));
      try {
        String line;
        while ((line = br.readLine()) != null) {
          answerString.add(line.trim());
        }
      } catch (IOException ioe){}
    } catch (FileNotFoundException ex){System.out.println("File not found");}
  }
```

```java
public void readFacStopsFile(){
  Vector facstops = new Vector();
  File outputFile = new File("facstops.txt");
  BufferedReader br = null;
  try{
    br = new BufferedReader(new FileReader(outputFile));
    try {
      String line;
      while ((line = br.readLine()) != null) {
        facstops.add(line.trim());
      }
      facstopsArray = facstops.toArray();
    } catch (IOException ioe){}
  } catch (FileNotFoundException ex){System.out.println("File not found");}
}


public void makeConstraints(){
  int count = 0;
  fileOutput.println(answerString.elementAt(0));
  for(int fileno=0; fileno<55; fileno++) {
  for(int i=0; i<facstopsArray.length; i++) {
    char charArray [];
    for(int j=count; j<answerString.size(); j++) {
      StringTokenizer tokens = new StringTokenizer(answerString.elementAt(j).toString());
      charArray = tokens.nextToken().trim().toCharArray();
      tokens = null;
      if(facstopsArray[i].toString().equals(""+charArray[1]+charArray[2]+charArray[3])) {
        String junk = answerString.elementAt(j).toString()+"<=1;";
        answerString.setElementAt(junk, j);
        String constraint = "";
        for(int k=count+1; k<=j; k++)
          constraint = constraint + answerString.elementAt(k);
        //System.out.println(constraint);
        fileOutput.println(constraint);
        count = j;
        break;
      }
    }
  }
  }
}


public static void main(String[] args) {
  facStops facStops1 = new facStops();
  //System.out.println(facStops1.answerString.toString());
}
}
```

```java
    String result = "";
    //String suffix ;
    while (tokens.hasMoreTokens()){
      String tokenValue = tokens.nextToken().trim();
      if(tokenValue.equals("<=1;"))
        result = result + "\b<=1;";
      else
        result = result + replaceString(tokenValue) + " +";
      //System.out.println(result);
    }
    //System.out.println(result);
    fileOutput.println(result);
  }
  String replaceString(String line) {
      return("X" + answerString.elementAt(Integer.parseInt(line.substring(1,4))-1) +
line.substring(4,line.length()));
  }
}
```

A.7 Code 7 (Output) (Java)

```java
package azmathoutput;

import java.io.*;
import java.util.*;

public class OutputFormat {

  PrintStream fileOutput;
  char charArray [];
  Object courseNumberArray [];
  Object departmentCodeArray [];
  Object courseCodeArray [];
  Object sectionNumberArray [];
  Object periodNumberArray [];
  Object daysArray [];
  Object startTimeArray [];
  Object endTimeArray [];

  public OutputFormat() {
  try {
     fileOutput = new PrintStream(new FileOutputStream("FinalOutput.out"));
       readCoursesFile();
       readPeriodsFile();
       readFiles();
   } catch (FileNotFoundException fe) {}
  }

  public void readFiles(){
    File outputFile = new File("output.txt");
    BufferedReader br = null;
    try{
     br = new BufferedReader(new FileReader(outputFile));
       try {
         String line;
```

```java
    } catch (FileNotFoundException ex){System.out.println("File not found");}
  }

  public void createOutput(String line){
    if(line.equals(""))
      return;
    charArray = line.toCharArray();
    String courseNo = ""+charArray[1]+charArray[2]+charArray[3];
    String periodNo = ""+charArray[4]+charArray[5]+charArray[6];
    String result = "";
    for (int i=0; i<courseNumberArray.length; i++)
      if(courseNo.equals(courseNumberArray[i].toString())) {
        result =
courseNumberArray[i].toString()+"\t"+departmentCodeArray[i].toString()+"\t"+courseCodeArray[i].toStri
ng()+"\t"+sectionNumberArray[i].toString();
        break;
      }
    for (int i=0; i<periodNumberArray.length; i++)
      if(periodNo.equals(periodNumberArray[i].toString())) {
        result = result
+"\t"+daysArray[i].toString()+"\t"+startTimeArray[i].toString()+"\t"+endTimeArray[i].toString();
        break;
      }
    fileOutput.println(result);

  }

  public static void main(String[] args) {
    OutputFormat outputFormat1 = new OutputFormat();
  }
}
```

[8] D de Werra, "The combinatorics of timetabling", *European Journal of Operational Research*, 96:504-513, 1997.

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