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Examination Timetable Scheduling Using Graph Coloring for Faculty of Science

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ABSTRACT: *Graph coloring is an important aspect of graph theory with great application in University timetable scheduling. The examination timetable scheduling maximizes the time and minimizes resources (venue and invigilators) to give effective output of the event. The constraint based approach method is implemented in scheduling examination timetable for Faculty of Science, Federal University Lokoja. Then the results on thirteen (13) departments give a 3-timeslot within twelve (12) days examination period with no students having two (2) examinations per day. In all, there is no conflict of venues and courses thereby giving an efficient scheduling process for the entire examination.*

KEYWORDS: adjacency matrix, graph coloring, examination timetable, constraint, maximization.

INTRODUCTION

Graph Theory uses a set of mathematical principles and formulae to examine the relationships among objects of interest (Zweig, 2016). In its simplest form, a graph consists of node and edges; nodes represent the objects of interest or entities in the real world, and edges represents the connections, interactions or relationships between them. Edges can be weighted, typically to represent the frequency of some sort, and they can also be unweighted (Diestel, 2010). Graph theory therefore is a branch of Mathematics that seeks to understand how different parameters and graphical structures are related to one another (Zweig, 2016).

Graphs are classified into directed and undirected, weighted and unweighted, cyclic and acyclic. The adjacency matrix can used to draw the graph with several applications and different adjacency matrices exist such as mixed hourglass adjacency matrix, see (Babarinsa, 2022; Bashir, 2023).

Let $A(G)$ denote the adjacency matrix of G, then $A(G) = a_{ij}$ is an n\times n matrix indexed by the vertices $\{v_1, v_2, \dots, v_n\}$ of G where $a_{ij} = 1$ if $\{v_i, v_j\}$ in E(G), otherwise $a_{ij} = 0$ (Babarinsa, 2019).

Mathematically, a simple graph $G = (V, E)$ consist of a set of vertices V and a set of undirected edges E (Bickle, 2020). A directed graph (or digraph) is a graph that contains only set of directed edges with the set of vertices V. A mixed graph $G = (V, E, A)$ is an ordered triple consisting of a set of vertices $V = \{v_1, v_2, \dots, v_n\}$ a set of undirected edges $E = \{e_1, e_2, \dots, e_n\}$ and a set of directed edges (Rosen, 2012; Babarinsa, 2022). A weighted graph or a network is a graph in which a number (the weight) is assigned to each edge, weights represents things like costs, lengths or capacities, courses and many more depending on the problem at hand (Prathik, 2016).

In Graph Theory, a directed acyclic graph (DAG) is a directed graph with no directed cycles. Thus, vertices and edges can be colored to deduce relationships between them.Directed acyclic graphs have scientific and computational applications, ranging from biology (evolution, family trees, and epidemiology), information science (citation networks) to computation or scheduling (Bang, 2008).

Assignment of labels (colors) to elements of a graph subject to constraints in graph coloring is a special case of Graph Theory and these assignments can be used to schedule tasks (Hansen, 2004).

It is a problem faced by most universities and colleges today which has attracted significant research interest over the years. It covers many different types of problems which have their own unique characteristics like time slot, venue, allocation of courses and invigilators (Qu, 2009).

A timetable is a schedule of events that organizes school activities throughout the day, week, term, semester or session. It is presented for events to take place and it does not necessarily imply the allocation of resources or time, but in real life, it is important to know if the resources available are sufficient enough or they are not sufficient for the given event taking place at a specific time (Pongcharoen, 2008).

Examination timetable

The examination timetable is a complicated tool beyond its perceived simplicity. It mainly connects and coordinates between four distinctive elements which are the students or candidates, teachers or invigilators, classrooms or venues and time-slots or periods (Zhang,2005). To resolve examination timetable problem, coloring of the courses and/or the departments are effective way.

(a) Graph coloring

Graph coloring is a way of coloring the vertices of a graph such that no two adjacent vertices have the same color (Solomon, 2020). This originates from coloring the maps of countries, where each face is literally colored and is called a planer graph. A planer graph is a graph that can be embedded in the plane such that its edges intercepts only at their end points, therefore, edges of a planar map do not cross each other (Lion, 2017). In mathematical representations, the first few positive or non-negative integers can be used as

the "colors". The famous four - color problem was found by Francis Gutherie in 1851, and the first results of graph coloring deal exclusively with planer graphs inform of coloring maps (Kubale, 2004). Although the four coloring problem was invented, it was only solved by Kenneth Appeal and wolfgang Haken, in 2003, after a century.

However, Heawood proved in 1890 the five color theorem that every planar map can be colored with no more than five colors (Appel, 2019; Van, 2003).

Graph coloring problem was proven to be an NP complete problem in 1972. NP complete problems have no algorithm for its graphs, but the optimal coloring will be found in a time bounded by a polynomial in the number of vertices in the graph (Ullman, 1976; Demaine, 2011). To have a good coloring such that no two vertices have the same color, a greedy coloring system that considers the vertices of a graph in sequence and assigns each node (vertex) its first available color will be used to determine the chromatic number of the graph (Dantas, 2016).While coloring the vertices, it doesn't matter which one comes first but the following steps can be used:

i. Check all the adjacent vertices, choose the first vertex having the most edges and assign a color to it
ii. Assign colors to the next vertex if they are not neighbours and a new color if they are connected.
iii. Go to the next and repeat the second step until there are no more vertices to color (Malaguti, 2008).

Graph coloring blends various essential and preferential conditions of timetabling which gives a practical application of graph coloring (Timothy, 2004).

(b) Timetable (University examination timetabling problem)

Timetabling or examination scheduling is a process of decision making which involves the assigning of the inadequate resources (courses) to tasks (rooms, lecturers) over a particular time (timeslots, periods) which is a priority in every educational institution (Yu, 2002 and Alghamdi, 2020). To meet the institutional needs and prerequisites while satisfying the necessities and wants of persons inside the institution, the timetable must be properly drafted (Qu, 2009). Timetable problem is NP Complete problem which can be scheduled using graph theory (Aldeeb, 2015). Exact approaches are not applicable in finding a close optimal solution to this problem due to the fact that the computational time needed will be exponentially increased with respect to the size of the problem (Alghamdi, 2020).

Generally, a timetabling or scheduling problem is applied to variety of areas with the assigning of limited resources occurring in different activities to meet the required objectives. The scheduling problem has been a tool used in various practical applications such as transportation, sports, mineral exploration, communication, aviation, educational institutions and military (Naujokaitis, 2013). Timetabling became a major concern in the University due to the complex nature of timetabling occurring as a result of the increasing

number of students and events with the restricted resources such as the limited staff, limited rooms and timeslots (Qu, 2009). The university timetabling problem can be categorized in two groups.

i. University Lecture Timetabling Problems.
ii. University Examination Timetabling Problem.

University examination timetabling problem is a peculiar scheduling problem in the university because of the time limits and large number of students with few lecturers. The university examination timetabling problem is the assigning of examinations to a limited number of available time or periods in such a way that there are no conflicts or clashes (Carter, 1997; Burke, 2012).

Examination timetabling problem is allocation of examination into a limited number of timeslots, while satisfying the maximum number of constraints which differs from institution to institution. Therefore, examination timetable problems can be approached based on their size, complexity and constraints (Qu, 2009).

This research work will be limited to scheduling only the examination timetable of Faculty of Science, Federal University Lokoja, Kogi State.

(c) Examination timetable scheduling

Examination scheduling has been in existence over a century but unique to each university in concern. Examination scheduling in Federal University Lokoja, specifically for faculty of science, has been hectic for both staff and students. The major problem is clash of venue and overscheduling of invigilators, for a particular examination and clashes of courses. This problem has been frequenting from 2020 as the number of students increase and the new departments created.

METHODOLOGY

Examination Timetable Model

The examination timetable is the problem of finding a schedule of a set of examinations within a given period of time while satisfying constraints over resources such as examination space and conflicts between examinations and rooms. These constraints are normally divided into hard and soft, where hard constraints must be satisfied for a feasible timetable, while soft constraints are desired to be satisfied as much as possible.

Hard constraints set conditions for the variables that are required to be satisfied which are:

i. Two examinations or courses cannot be scheduled into one-time slot when there are a number of common students sitting for the examination.
ii. The number of students sitting for examination in a particular time should not exceed the number of available seats.

iii. No invigilator(s) should be assigned to invigilate two different examinations at the same time.

Soft constraints on the other hand can be violated, they are constraints desired to be satisfied, but not necessary.

Examinations with the largest number of students should be scheduled early for sufficient marking time.

i. Examinations for each student should be spread as far apart as possible.
ii. No more than 13 examinations taking place simultaneously.
iii. Every exam must be assigned to a room(s) of sufficient size and assigned an invigilator(s).
iv. Certain exams must be scheduled into specific time slots or rooms.
v. Certain exams must take place simultaneously.

This research will work towards satisfying all hard constraints. Thus, soft constrains will be used as the measurement which will evaluate either the timetable is good and practical or not. Soft constraints are considered as preferences which will fulfil some user requirements to maximize the perfection of timetable. Such assumptions and constraints are distinct from other graph coloring problems. We have summarized these assumptions and constraints as follows:

The number of timeslot (TS) per day (exam period) can be set by the administrator. TS depend on department specific constraints. The number of concurrent exams or concurrency level Np depends on the number of available rooms, and the availability of faculty member to conduct the examination. Np is determined by the registrar's office. Here Np is a system parameter, and the exam scheduling algorithm has been examined with several Np values.

i. A student shall not allow for more than x exams per day and this is referred as a system tunable parameter.
ii. A student shall not have a gap of more than y days between two consecutive exams, and it also determined by department (another fairness requirement).
iii. The schedule shall be done in the minimum possible time slot. The exam schedule is an outcome of the scheduling algorithm.

Faculty of Science examination timetable

The students' handbook from these 13 departments will be collected, for comprehensive and accurate compilation of courses offered by the students. The examinations will be spread to 2 weeks with each day scheduled to hold three different examinations (morning, afternoon and evening). These 13 departments (with codes) in the faculty of science, Federal University Lokoja, Kogi state are:

Biological science (BIO)
Biotechnology (BTC)
Biochemistry (BCH)

Botany (BOT)
Chemistry (CHM)
Computer science (CSC)
Geology (GEY)
Industrial chemistry (ICH)
Mathematics (MTH)
Microbiology (MCB)
Physics (PHY)
Statistics (STA)
Zoology (ZOO)

The files for students and listing all courses studies by student is use for scheduling for the examination. Each course corresponds to a node in the matrix. Set the concurrency level of each node to the number of sections for the given course. In this case, each node implies the course, and find the set of adjacent nodes, including the weight of the edges connecting the node to its adjacent nodes. Fill the weight matrix with course codes. Create a graph using the weight matrix. Find the degree for each node in the graph. Color the graph nodes in the weight matrix in a descending order on the basis of degree of nodes. Nodes with similar degrees are ordered based on the largest weight in its adjacency list.
The algorithm to be used in this work is an improved version of constraint based algorithm via graph coloring proposed by Atahar,in 2017 which suit the problem of timetable in Faculty of Science, Federal University Lokoja. This algorithm will be implemented on SAGE software.

Implementation
To achieve the adjacency matrix, the main component in drawing graph, the departments and the course codes are arranged in rows and columns and the corresponding association between them are represented in 1's and 0's. If it is 1 then the department offers the course otherwise 0's. An arc is indicated if a department float a course offered by other departments but the latter department does not offer a course by the former department, otherwise an edge if the two departments float a course offer by both.
The adjacency matrix of all the academic levels for both first semester and second semester were implemented in SAGE, the results are given in Table {11} to Table {12} and Figure {fig5} to Figure {fig15} with the available venue of Table {123} as follows:

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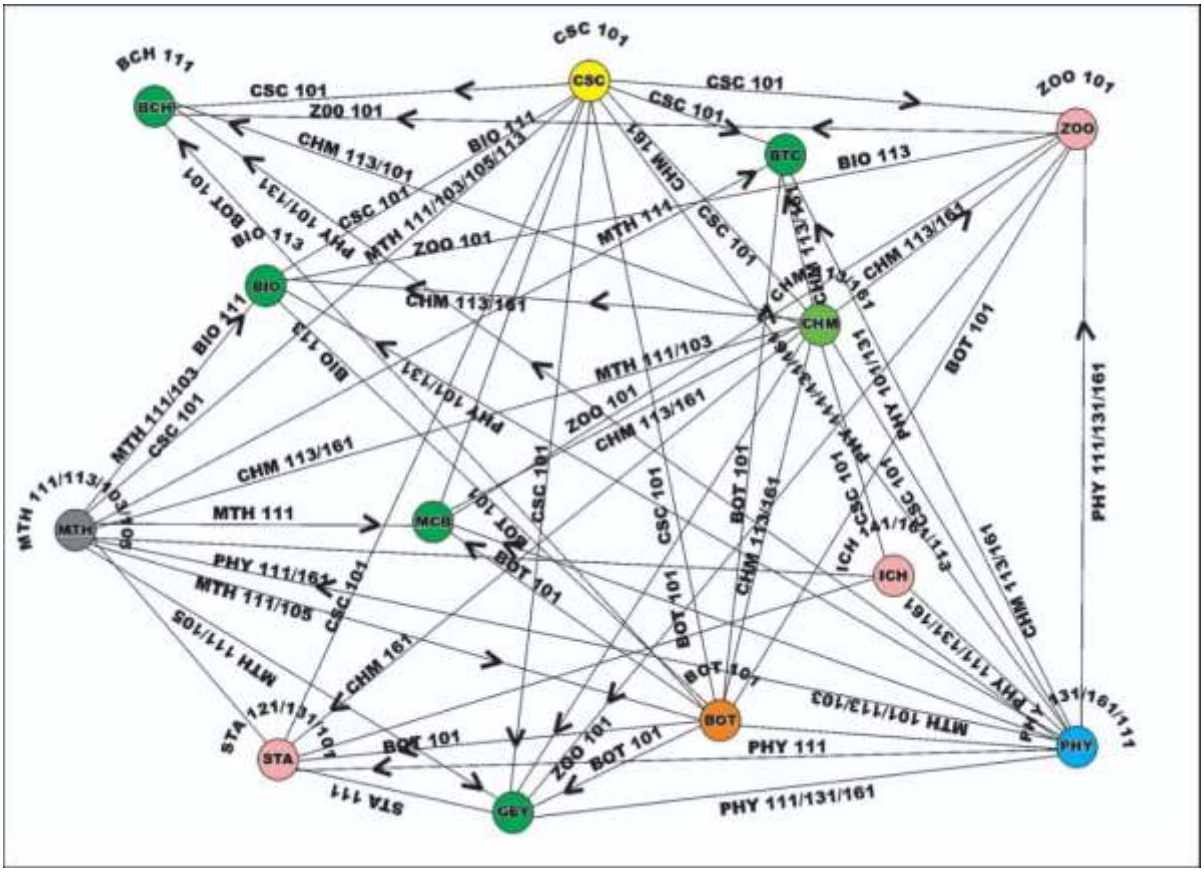

Figure 1: Graph coloring of First Semester 100level examination

1ST SEMESTER												
100 LEVEL COURSES												
PINK	**GREEN**						**LEMON**		**YELLOW**	**ORANGE**	**BLUE**	**PURPLE**
ZOO 101	STA 121 101 113 131	GEY 101	BIO	BCH 111	MCB	BTC	ICH 141 161 113	CHM 113 161	CSC 101	BOT 101	PHY 131 161 111	MTH 111 113 115

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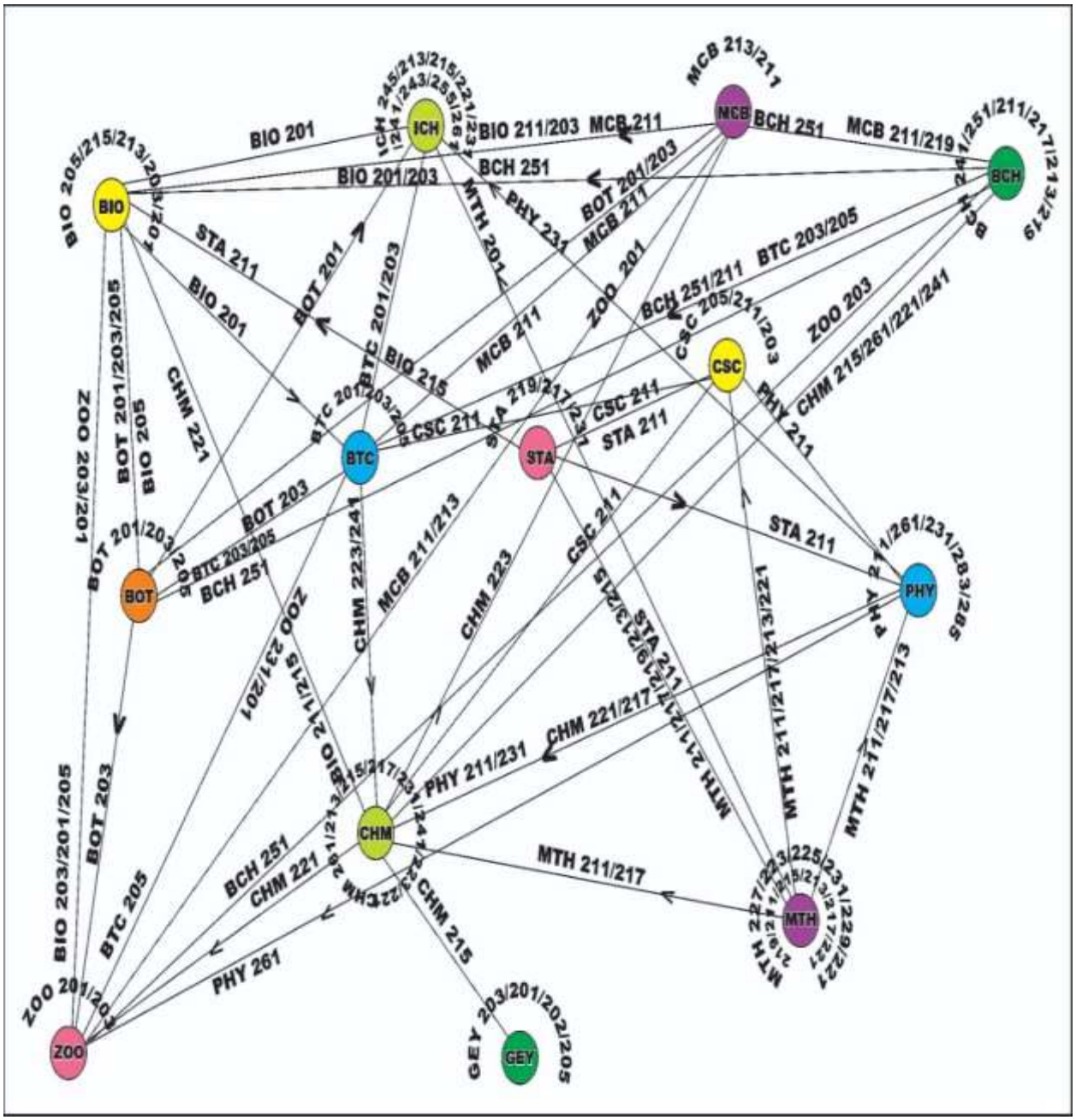

Figure 2: Graph coloring of First Semester 200level examination

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200 LEVEL											
PINK		**GREEN**		**LEMON**		**BLUE**		**YELLOW**		**ORANGE**	**PURPLE**	
ZOO 201 203	STA 211 219 217 231	BCH 213 215 217 219 241 251	GEY 201 203 207 205 209	CHM 261 213 217 231 241 223 221	ICH 245 213 215 221 231 241 243 255 261	PHY 211 261 231 283 285	BTC 201 203 205	BIO 205 215 213 203 211	CSC 205 211 203	BOT 201 203 205	MTH 221 219 211 215 213 217	MCB 213 211 219

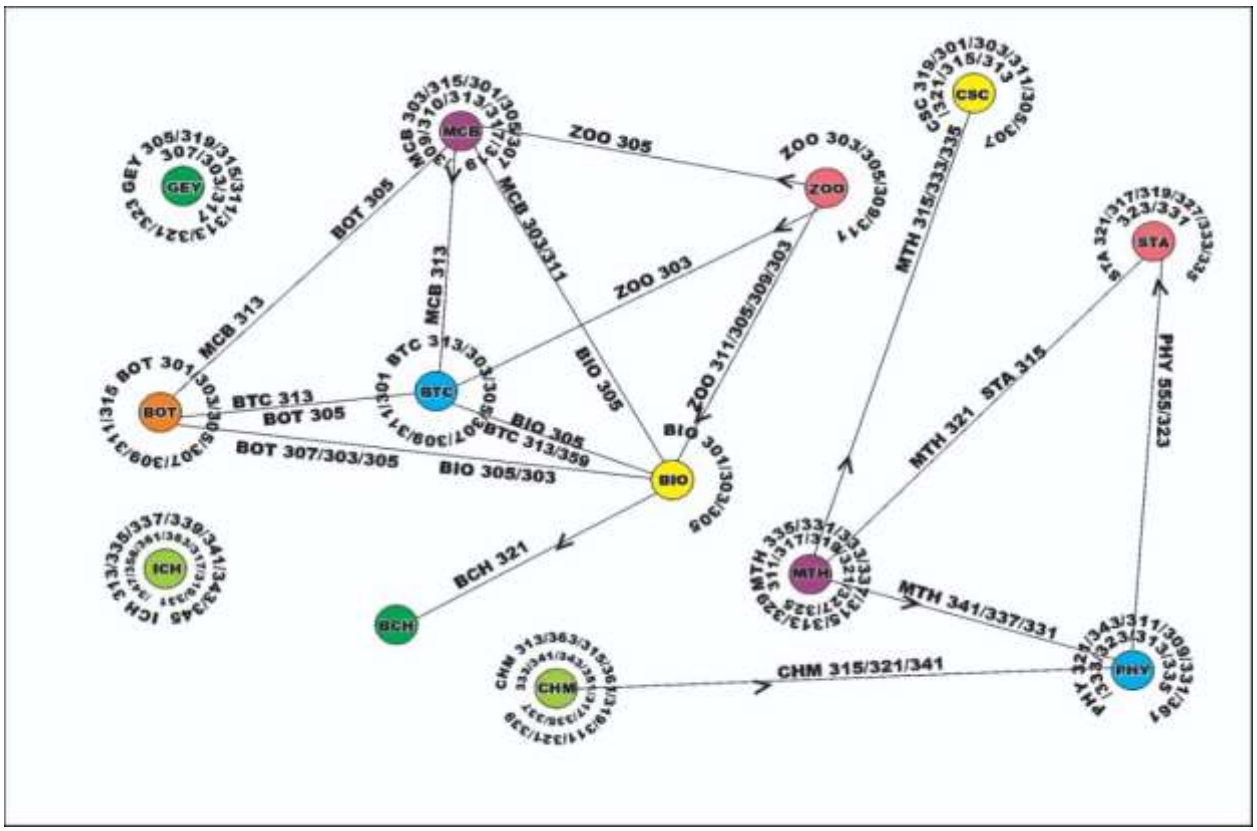

Figure 3: Graph coloring of First Semester 300level examination

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300level											
PINK		**GREEN**		**LEMON**		**BLUE**		**YELLOW**		**ORANGE**	**PURPLE**	
ZOO	STA	BCH	GEY	CHM	ICH	PHY	BTC	CSC	BIO	BOT	MTH	MCB
337	321		305	319	313	321	313	319	301	321	335	315
331	313		319	361	335	343	303	301	303	325	331	301
335	305		315	315	337	311	305	303	305	321	341	303
305	310		311	363	339	309	307	311		303	333	305
311	325		313	313	341	331	309	305		305	339	307
309	317		321	311	343	361	311	307		307	343	309
303	319		323	321	345	333	301	321		309	337	313
	327		307	341	347	323	313	315		311	315	317
	335		301	339	358	335		313		315	313	319
	333		309	333	361	313					317	310
	329		303	342	363						319	
	323		317	351	369						321	
	331			317	317						327	
				335	319						323	
				337	331						325	
											329	

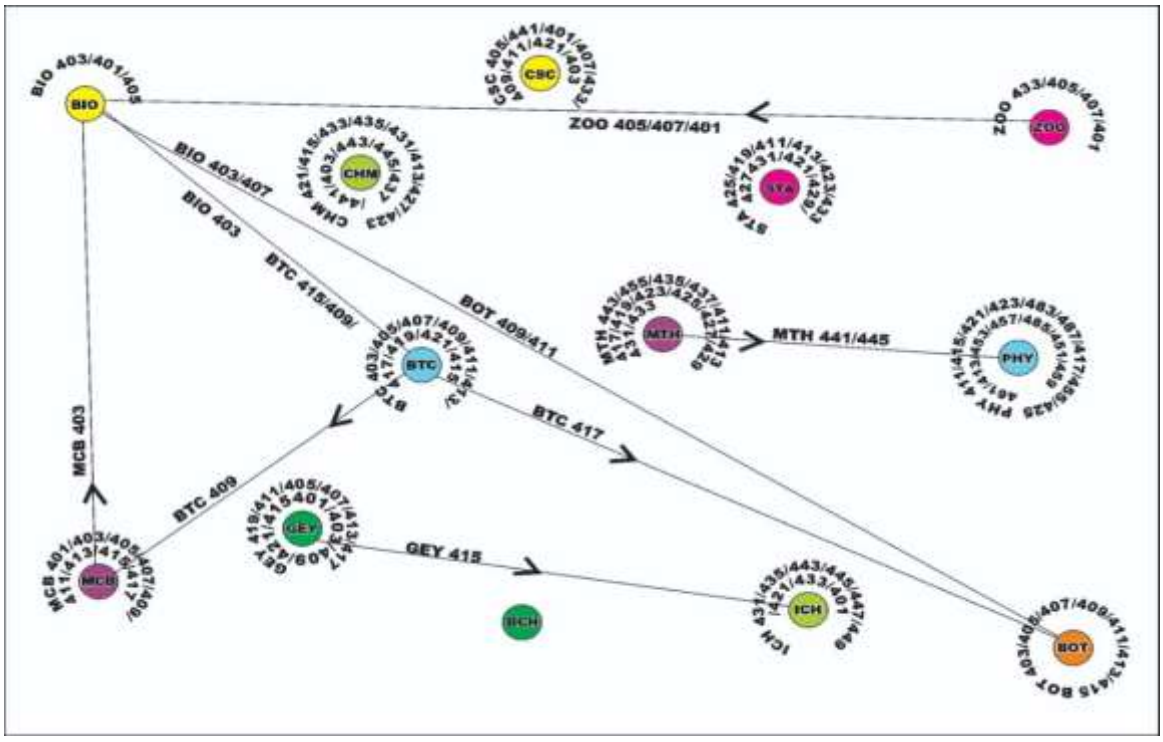

Figure 4: Graph coloring of First Semester 400level examination

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400 LEVEL												
PINK		**GREEN**		**LEMON**		**BLUE**		**YELLOW**		**ORANGE**	**PURPLE**	
ZOO	STA	BCH	GEY	CHM	ICH	PHY	BTC	CS	BIO	BOT	MTH	MCB
433	425		419	427	401	441	409	C	413	421	443	410
411	419		411	423	431	461	403	405	411	425	453	401
435	411		405	421	435	413	405	403	417	423	455	403
431	413		407	415	443	453	407	441	403	409	451	405
437	423		413	433	445	421	411	401	405	411	447	407
433	415		417	435	447	481	413	407		403	445	409
405	417		401	431	448	457	415	433		405	441	411
407	431		403	413	421	450	417	411		407	449	413
401	421		409	441	433	485	419	421		413	457	415
	427		421	403		451	421	409		415	459	417
	429		415	443		459						
	433			437		455						
				445		401						
						411						
						415						
						425						
						417						
						423						
						483						
						487						

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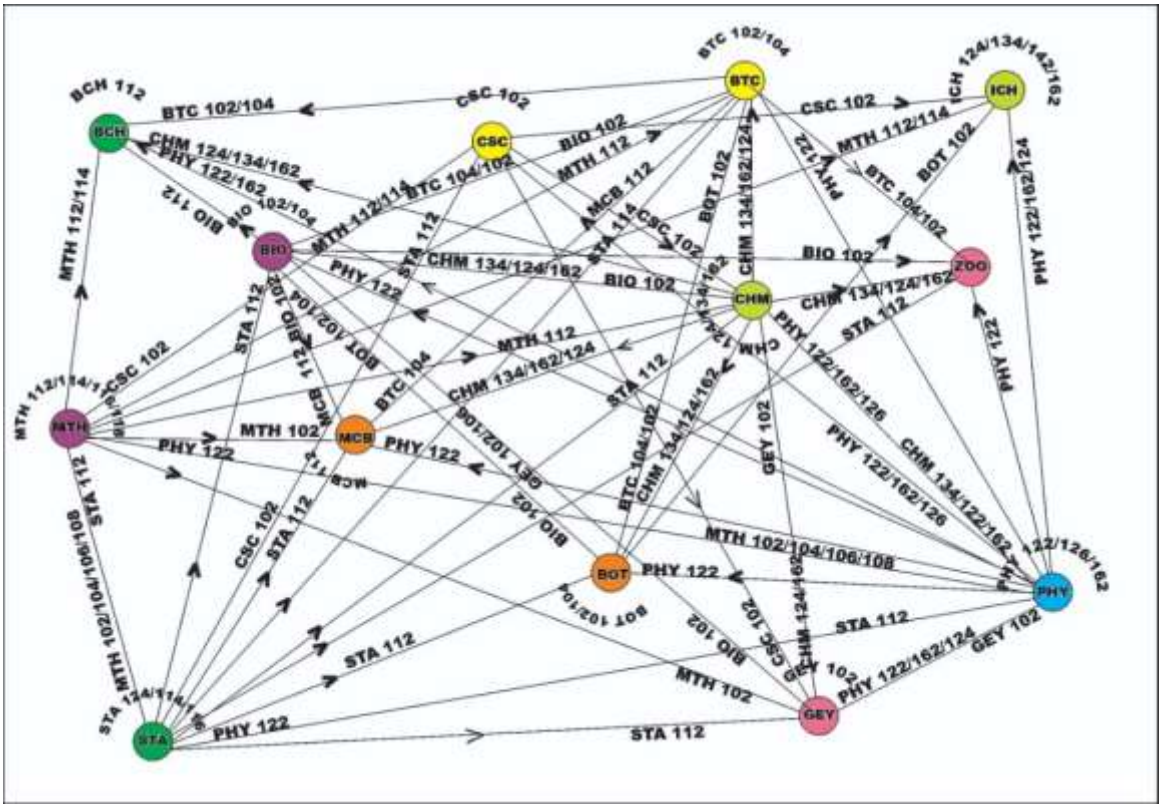

Figure 5: Graph coloring of Second Semester 100level examination

100 LEVEL											
PINK			**GREEN**		**LEMON**		**BLUE**	**YELLOW**		**ORANGE**		**PURPLE**
ZOO	GEY 102	BTC 102 104	STA 124 114 116 112	BCH 112	ICH 124 134 142 162	CHM 124 134 162	PHY 122 126 162	BIO 102 112	CSC 102	MCB 112	BOT 102 104	MTH 112

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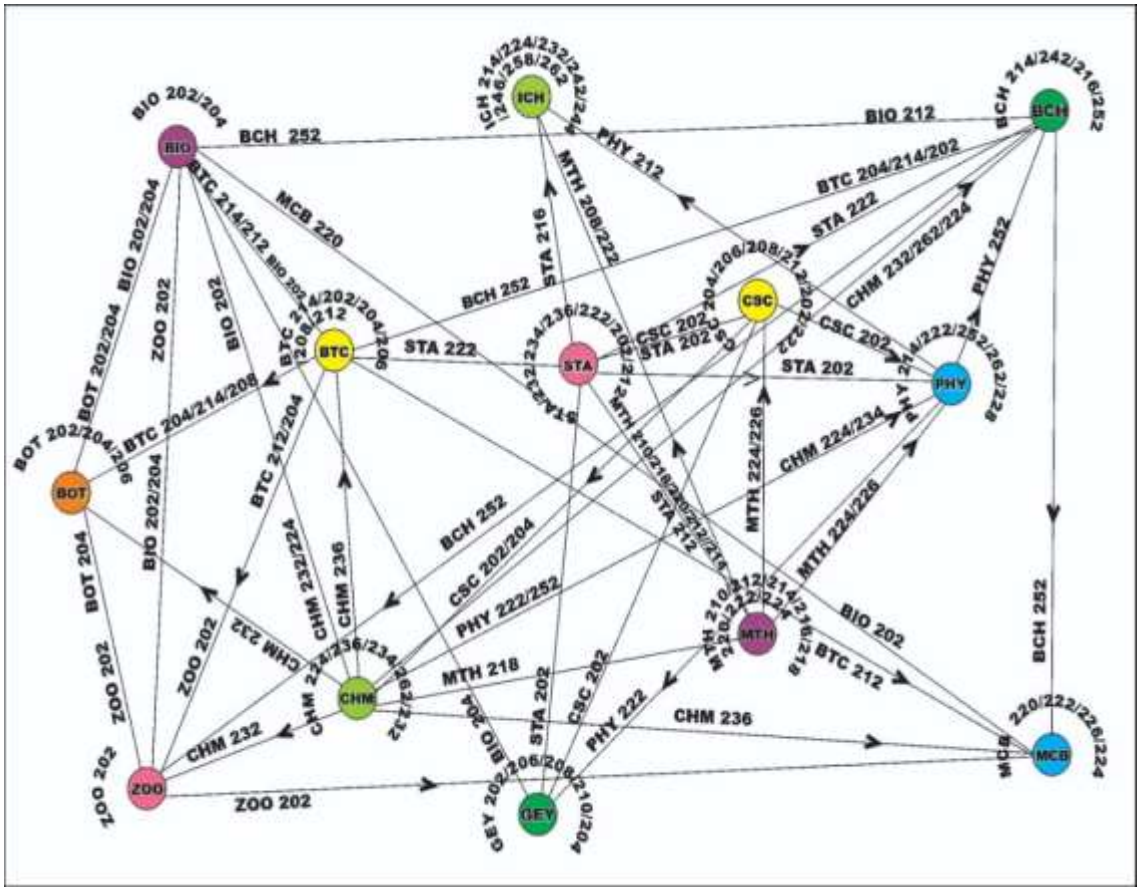

Figure 6: Graph coloring of Second Semester 200level examination

200 LEVEL												
PINK		**GREEN**		**LEMON**		**BLUE**		**YELLOW**		**ORANGE**		**PURPLE**
ZOO 202	STA 232 234 236 222 202 212	GEY 202 206 208 210 204	BCH 214 242 216 252	CHM 224 236 234 262 232	ICH 214 224 232 242 244 246 258 262	PHY 214 222 252 262 228	BTC 214 202 204 206 208 212	BIO 204 212 216	CSC 204 206 208 212 202	MCB 220 222 226 224	BOT 202 204 206	MTH 210 212 214 216 218 220 222 224

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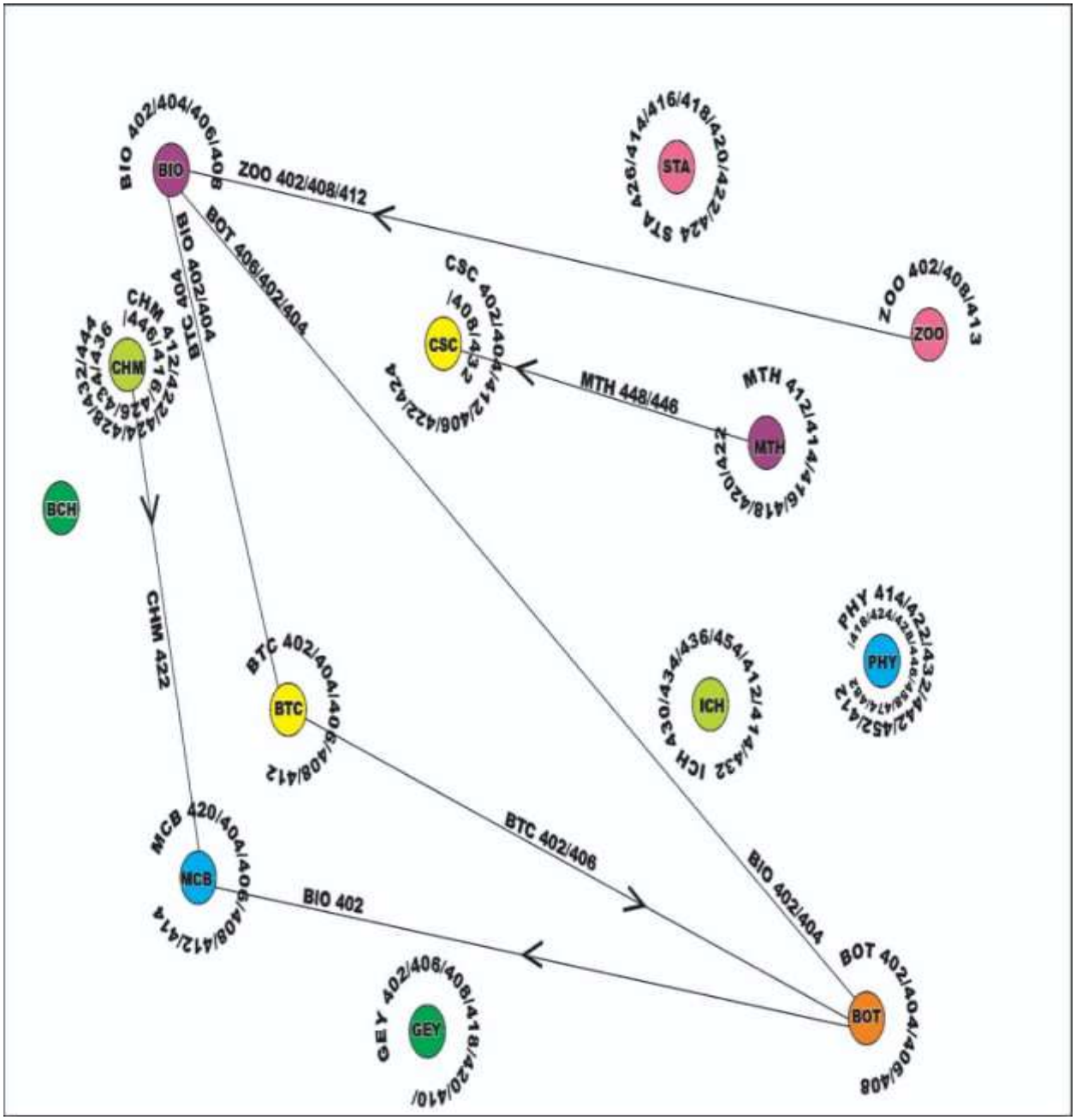

Figure 7: Graph coloring of Second Semester 400level examination

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400LEVEL

PINK		GREEN		LEMON		BLUE		YELLOW		ORANGE	PURPLE	
ZOO 402 408 412	STA 426 414 416 418 420 422 424	GEY 402 406 408 412 414 418 420 404	BCH	CHM 412 422 424 428 432 444 446 416 426 434 436	ICH 430 434 436 454 412 414 432	PHY 414 422 432 442 452 412 418 424 428 436 458 458 474 482	BTC 402 404 406 408 412	BIO 402 404 406 408	CSC 402 404 412 406 422 424 408 432	BOT 402 404 406 408	MTH 412 414 416 418 420 422	MCB 420 402 404 406 408 412 414

DAY	VENUE	DEPARTMENT	8.00AM-1100AM	11.30AM-2.30PM	3.00PM-6.00PM
DAY 1	LLR 5/LLR 6	BIOLOGICAL SCI.	ZOO 405	BOT 307	BCH 251
		BIOCHEMISTRY	ZOO 101		BCH 251
		BIOTECHNOLOGY	ZOO 101	BTC 411	BCH 251
	LT 1	BOTANY	ZOO 101	BOT 307	BCH 251
	LR1/LR3/LR4	CHEMISTRY	CHEM 427	CHEM 319	CHEM 343
	LT 2	COMPUTER SCI	CSC 421	CSC 411	MTH 441
	FLH 1/FLH2/GEY LAB	GEOLOGY	ZOO 101	GEY 419	GEY 203
		INDUSTRIAL CHEM	MTH 115/ ICH 449	ICH 339	ICH 363
	LLR 1/OLD BIO LAB	MATHEMATICS	MTH 115/ MTH 425	MTH 331	MTH 441
		MICROBIOLOGY	ZOO 101	MCB 309	BCH 251
	OLD CHM/OLD BIO LAB/LLR6/LT1	PHYSICS	MTH 115/ PHY 461	MTH 331	MTH 441
	NA5 /NA6	STATISTICS	STA 113	STA 425	STA 433
	NA9/NA10/NA11/NA12	ZOOLOGY	ZOO 101/ ZOO 405		

DAY 2	LLR5/LLR6	BIOLOGICAL SCI.	CHM 113	ZOO 311	BTC 409
		BIOCHEMISTRY	CHM 113		BCH 217
		BIOTECHNOLOGY	CHM 113	BTC 303	BTC 409
	LT2	BOTANY	CHM 113	BOT 407	BOT 325
	LLR3/LLR4/LLR 5/LLR6	CHEMISTRY	CHM 113/ CHM 403	CHM 333	CHM 341
	LT 1/ LT 2	COMPUTER SCI	CHM 113	CSC 433	CSC 409
	FLH 1/ GEY LAB	GEOLOGY	CHM 113	GEY 411	GEY 205
		INDUSTRIAL CHEM	ICH 141/ ICH 421	ICH 361	ICH 337
	LLR1/LLR5	MATHEMATICS	MTH 213	MTH 317	MTH 411
		MICROBIOLOGY	CHM 113	MCB 311	BTC 409
	FLH 2	PHYSICS	MTH 213/ PHY 411	PHY 311	CHM 341
	LT1/LLR1/LLR6	STATISTICS	MTH 213	STA 319	STA 217
	LLR1/LLR3/LLR 4	ZOOLOGY	CHM 113	ZOO 311	ZOO 203
DAY 3	LT1	BIOLOGICAL SCI	PHY 131/ ZOO 309	MCB 303	CHM 223
		BIOCHEMISTRY	PHY 131	BCH 219	
		BIOTECHNOLOGY	PHY 131 / BTC 307	BTC 417	CHM 223
		BOTANY	BOT PHY 131	BTC 417	BOT 413
	OLD CHM LAB/LT2/LLR5/ LLR6	CHEMISTRY	PHY 131/ CHM 441	CHM 339	CHM 223
	LLR3/LLR4/OL D BIO LAB/LT1	COMPUTER SCI	PHY 131	CSS 313	CSC 407
	FLH 1/LLR3/LLR4	GEOLOGY	PHY 131	GEY 209	GEY 319
		INDUSTRIAL CHEM	ICH 243	STA 101/ ICH 358	ICH 213
	LLR6/FLH1/FLH 2/LT2	MATHEMATICS	PHY 131/MTH 423	MTH317	MTH 413
		MICROBIOLOGY	PHY 131/ MCB 415	MCB 303	CHM 223
	LLR1/LLR5	PHYSICS	PHY 131/ PHY 361	MTH 317	CHM 223/ PHY 401
	LLR3/LLR6/NA5 /NA6	STATISTICS	STA 327	STA 101	STA 419
	NA8/9/10/11/12	ZOOLOGY	PHY 131/ ZOO 309	STA 101	CHM 223
DAY 4	LT2	BIOLOGY SCI	CSC 101/ BIO 405	ZOO 303	MCB 403
		BIOCHEMISTRY	CSC 101		
		BIOTECHNOLOGY	CSC 101/ BTC 311	ZOO 303	BTC 203
	LT2	BOTANY	CSC 101/ BIO 405	BOT 315	BOT 205
	LT1/LT2	CHEMISTRY	CSC 101/ CHM 351	MTH 217/ CHM 445	PHY 231
	LLR3/LLR4/ OLD BIO LAB/COMP LAB	COMPUTER SCI	CSC 101	MTH 217	CSC 315
	LT1/LT2	GEOLOGY	CSC 101	GEY 415	GEY 305
		INDUSTRIAL CHEM	CSC 101/ ICH 369	GEY 415	PHY 231
	LLR1/MTH LAB/LLR5/OLD BIO LAB	MATHEMATICS	CSC 101/ MTH 435	MTH 217	MTH 329
		MICROBIOLOGY	CSC 101	MCB 417	MCB 403
	LT1/LT2/FLH2	PHYSICS	CSC 101/ PHY 333	MTH 217/ PHY 455	PHY 231
	LT1/LLR5/LLR6	STATICTIS	CSC 101	STA 317	STA 411

	NA7/8/9/10/11/12	ZOOLOGY	CSC 101	ZOO 303	
DAY 5	FLH1/FLH2	BIOLOGICAL SCI	BOT 101	BIO 203	BIO 303
	LLR1/LLR3/LLR4/FLH1/2	BIOCHEMISTRY	BOT 101	BIO 203	CHM 261
	LLR5	BIOTECHNOLOGY	BOT 101/BTC 301	CSC 211	BTC 407
	LLR6	BOTANY	BOT 101	BIO 203	BIO 303
	LT1	CHEMISTRY	CHM 317/BOT 101	CSC 211/CHM 437	CHM 315
	LT2	COMPUTER SCI	CSC 409/BOT 101	CSC 211	CSC 301
	NA7/8/9/10/11/12	GEOLOGY	BOT101	GEY 405	GEY 317
	COMP/MTH LAB	INDUSTRIAL CHEM	BOT 101/ ICH 317	ICH 431	ICH 313
	FLH 1/FLH2	MATHEMATICS	MTH 219	MTH 325	MTH 225
	NA3/4/5/6	MICROBIOLOGY	BOT 101	BIO 203	MCB 409
	PG CHM/PG PHY LAB/NA3/4	PHYSICS	MTH 223/ PHY 415	PHY 413	CHM 315
	NEW BIO LAB 1/2/038/039 UPSTAIR	STATISTICS	MTH 219	CSC 211	STA 413
	LLR3/LLR4//R1/RM040/041/042/043	ZOOLOGY	BOT101	BIO 203	
DAY 6	LLR5/LLR6/LT2	BIOLOGICAL SCI	MTH 111	BTC 309	MCB 212
	NA10/NA11	BICHEMISTRY	BCH 241		MCB 211
	NA12	BIOTECHNOLOGY	MTH 111/ BTC 301/ CSC 101	BTC 309	MCB 211
	NA8	BOTANY	MTH 111	BOT 311	MCB 211
	LLR3/LLR4/OLD BIO LAB/LT1	CHEMISTRY	MTH 111/ CHM 335	CHM 231	CHM 311
	LT1/LLR3/LLR5/LLR6	COMPUTER SCI	MTH 111	CSC 401	CSC 321
	NA6/LLR1/FLH1/FLH2	GEOLOGY	MTH 111	GEY 303	GEY 407
	FLH1/LT2	INDUSTRIAL CHEM	MTH 111/ ICH 319	ICH 221	ICH 347
	LLR1	MATHEMATICS	MTH 111/ MTH 433	MTH 315	MTH 215
	FLH1/FLH2	MICROBIOLOGY	MTH 111/ MCB 413	MCB 305	MCB 211
	LLR6/NA3/NA4/LT1	PHYSICS	MTH 111/PHY 323	PHY 343	PHY 453
	LLR5/NEW BIO LAB ½	STATISTIC	MTH 111 /CSC101	STA 331	MTH 215
	LT2	ZOOLOGY	MTH 111		MCB 211
DAY 7	LLR4/LLR5	BIOLOGICAL SCI	CHM 161	MCB 211	BIO 301
	LLR3/LLR4/LY1	BIOCHEMISTRY	CHM 161	CHM 217	BCH 111
	LLR4/OLD BIO LAB	BIOTECHNOLOGY	CHM 161	BTC 405	BTC 421
	NA5/NA6	BOTANY	CHM 161	BOT 403	BOT 309
	LT1/LT2	CHEMISTRY	CHM 161/ CHM 413	CHM 217	CHM 321
	LT1/LLR1	COMPUTER SCI	CHM 161	CSC 441	CSC 303
	LT2/OLD CHM LAB/NEW BIO LAB1/2/PG CHM LAB/PG PHY LAB	GEOLOGY	CHM 161	CHM 217	GEY 101

	OLD CHM LAB/NA1/NA2	INDUSTRIAL CHEM	ICH 161/ ICH 447	ICH 215	ICH 335
	LLR3/FLH2/LT2	MATHEMATICS	MTH 419	MTH 317	MTH 431
	NEW BIO LAB UPSTIA ROOM 041/042/043	CHEM DEUCATION/MATH EDUCATION	PHY 111		
	FLH1/NEW BIO LAB UPSTAIR ROOM 041/042/043	MICROBIOLOGY	CHM 161	MCB 311	MCB 405
	LLR6/LLR1/COMP LAB	PHYSICS	CHM 161/ PHY 421	CHM 217/ PHY 425	CHM 321
	LLR5/FLH1/FLH2	STATISTICS	STA 231	STA 423	STA 121
	LT2/NA12	ZOOLOGY	CHM 161		
DAY 8	LLR3/LLR4/LLR5	BIOLOGY SCI.	PHY 161/ ZOO 401	BOT 201	CHM 161/BTC 203
	LLR3/FLH1/FHL2/LLR5	BIOCHEMISTRY	PHY 161		BTC 205
	LT2/LLR1	BIOTECHNOLOGY	PHY 161/ BTC 413	CHM 241	BTC 205
	LLR4/LLR6	BOTANY	PHY 161	BOT 201	BTC 205
	FLH1/FLH2	CHEMISTRY	PHY 161/ CHM 337	CHM 241/ CHM 443	CHM 313
	LT2	SCIENCE EDUC	PHY 161		
	LLR1/COMP LAB/LLR5/LLR6	COMPUTER SCI	PHY 161	CSC 307	MTH 335
	FLH 1/FLH2/LT1/NA1	GEOLOGY	PHY 161	GEY 307	GEY 413
	OLD BIO LAB/LTR6/LT2	INDUSTRIAL CHEM	ICT 331/PHY 161	ICH 241	ICH 345
	LT1(NA5/5/7/8)	MICROBIOLOGY	PHY 161	BOT 201	MCB 305
	LT1/(NA5/6/7/8)	MATHEMATICS	MTH 455		MTH 335
	NA3/4/LLR3	PHYSICS	PHY 161/PHY 457	PHY 335	PHY 261/PHY 417
	NA11/NA12/LLR1	STATISTICS	STA 131	STA 431	STA 323
	NEW BIO LAB UPSTAIRS ROOMS 038/039/040/041/NA6	ZOOLOGY	PHY 161/ZOO 401		BTC 205
DAY 9	LT2	BIOLOGICAL SCI.	BOT 305	BIO 205	BTC 313 MCB 211/219
	NA3/FLH1/FLH2	BIOCHEMISTRY	MTH 113		
	NA 4	BIOTECHNOLOGY/ GEOGRAPHY	BOT 305	BTC 403	BTC 313
	NA 11	BOTANY	BOT 305	BIO 205	BTC 313
	LT1	CHEMISTRY	MTH 113/ CHM 431	BIO 205	CHEM 423
	LLR3/LLR2	COMPUTER SCI.	MTH 113/ CSC 409	CSC 205	MTH 333
	FLH1/FLH2/LT/LR4	GEOLOGY	GEY 417	GEY 421	GEY 323
	OLD CHEM LAB/LLR6	INDUSTRIAL CHEM.	ICH 113/ ICH 445	ICH 401	ICH 261
	LT1	MICROBIOLOGY	MCB 401	MCB 315	MCB 307
	LLR1/LLR5	PHYSICS	MTH 113/ PHY 485	PHY 285/ PHY 423	PHY 321

	NA12/LT2	ZOOLOGY		BIO 205	
DAY 10	LLR1/LT1	BIOLOGICAL SCI.	PHY 111/ BOT 411	BIO 305	BIO 403
		BIOCHEMISTRY			CHM 261
		BIOTECHNOLOGY	PHY 111/ BTC 419	BIO 305	BIO 403
	LT2	BOTANY	PHY 111/ BOT 411	CHM 365	BOT 415
	LT1/LT2	CHEMISTRY	CHEM 213/ CHEM 319	CHM 215/217	CHM 261
	LT2/NA6	COMPUTER SCI.	PHY 111	CSC 319	CSC 405(NA6)
	LLR3/ LLR4/LLR5/LLR 6	GEOLOGY	PHY 111	GEY 401	GEY 409 (LLR 5/6)
	NA5/LLR3/FLH1	INDUSTRIAL CHEM.	PHY 111/ICH 443	ICH 343	ICH 245
	LLR5/FLH2	MATHEMATICS	PHY 111/MTH 337		MTH 319
		MICROBIOLOGY	MCB 410	BIO 305	MCB 319
	LLR5/LLR6/NA4	PHYSICS	PHY 111/PHY 483	PHY 283	CHM 261/ PHY 451
	LT1/LLR6/NA4	STATISTICS	PHY 111	STA 427	STA 333
	LLR3/LLR4	ZOOLOGY	PHY 111		
DAY 11	LT2	BIOLOGICAL SCI.	ZOO 201	BIO 201	ZOO 407
	OLD BIO LAB	BIOCHEMISTRY		BIO 201	ZOO 407
		BIOTECHNOLOGY	ZOO 201	BIO 201	MCB 313
		BOTANY	BOT 405	BIO 201	MCB 313
	LT2/FLH1/FLH2	CHEMISTRY	CHM 421	BIO 201	CHM 361
	LT2/LT1	COMPUTER SCI.	CSC 403	CSC 203	CSC 305
	LT1/(NEW BIO LAB UPSTAIRS ROOMS) 038/039/040	GEOLOGY	GEY 321	GEY 311	GEY 201
	FLH1/NA8/NA9	INDUSTRIAL CHEM.	ICH 433/ ICH 231	BIO 201	ICH 341
	LLR5/LT1	MATHEMATICS	MTH 443	MTH 417	MTH 321
	NA10/11/12	MICROBIOLOGY	ZOO 201/ MCB 411	BIO 201	MCB 313
	LLR5/LLR6	PHYSICS	PHY 313	MTH 417	PHY 487
	LLR3/LLR4/LLR 1	STATISTICS	STA 219	STA 335	MTH 321
	LLR2/COMP LAB/LT2	ZOOLOGY	ZOO 201	BIO 201	ZOO 407
DAY 12	LT2/FLH1	BIOLOGICAL SCI.	BTC 415	BOT 409	ZOO 305
	LLR3	BIOCHEMISTRY			BCH 215
	LT2/LLR1	BIOTECHNOLOGY	BTC 415	BTC 201	BTC 305
		BOTANY	BOT 303	BTC 409	
	LT1	CHEMISTRY	CHM 415	PHY 211	CHM 433
	LLR5/LLR6	COMPUTER SCI.	MTH 211	PHY 211	CSC 311
	LT1/LT2/NEW BIO LAB1	GEOLOGY	GEY 315	GEY 403	GEY 207
			CHM 221 /STA 211		

	LLR5/LLR6/LLR 4	INTEGRATED SC/CHEM. EDUC.		MTH 227	CHM 241
	FLH1/FLH2/LLR 3/PHY LAB	INDUSTRIAL CHEM.	MTH 211	ICH 435	1CH 255
	LT1/LT2/NA10/1 1/12	MATHEMATICS	MTH 211	MTH 327	MTH 437
		MICROBIOLOGY	MCB 211	MCB 301	ZOO 305
	LT2/FLH2/NA7/ 8/9	PHYSICS	PHY 459/ MTH 211	PHY 211	PHY 309
	LT1/LT2/NA4/5/ 6	STATISTICS	MTH 211	STA 429	STA 321
		ZOOLOGY			ZOO 305

DAY	VENUE	DEPARTMENT	8.00AM-1100AM	11.30AM-2.30PM	3.00PM-6.00PM
DAY 1	LLR 5/LLR 6	BIOLOGICAL SCI.	BIO 406	ZOO 402	ZOO 202
		BIOCHEMISTRY	BCH 104	CHM 262	
		BIOTECHNOLOGY	BTC 104	BTC 406	ZOO 202
	LT 1	BOTANY	BTC 104	BTC 406	ZOO 202
	LR1/LR3/LR4	CHEMISTRY	GEY 102	CHEM 262	
	LT 2	COMPUTER SCI	CSC 222	CSC 412	
	FLH 1/FLH2/GEY LAB	GEOLOGY	GEY 102		
		INDUSTRIAL CHEM		ICH 242	
	LLR 1/OLD BIO LAB	MATHEMATICS	MTH 412		MTH 222
		MICROBIOLOGY	BTC 104	MCB 402	ZOO 202
	OLD CHM&OLD BIO LAB/LLR6/LT 1	PHYSICS	GEY 102	PHY 414	
	NA5 &NA6	STATISTICS	STA 418		STA 232
	NA9/NA10/N A11/NA12	ZOOLOGY	BTC 104	ZOO 402	ZOO 202
DAY 2	LLR5&LLR6	BIOLOGICAL SCI.	STA 124		BIO 202
		BIOCHEMISTRY	BCH 102		BIO 202
		BIOTECHNOLOGY	BTC 412	BTC 402	BIO 202
	LT2	BOTANY	STA 124	BTC 402	BIO 202
	LLR3/LLR4/L LR5/LLR6	CHEMISTRY	STA 124	CHM 436	BIO 202
	LT 1/ LT 2	COMPUTER SCI	STA 124	CSC 404	
	FLH 1/ GEY LAB	GEOLOGY	STA 124	GEY 402	
		INDUSTRIAL CHEM	ICH 142	ICH 432	
	LLR1/LLR5	MATHEMATICS	STA 124		MTH 212
		MICROBIOLOGY	STA 124	MCB 414	BIO 202
	FLH 2	PHYSICS	STA 124	PHY 442	

	LT1/LLR1/LLR6	STATISTICS	STA 124	STA 424	MTH212
	LLR1/LLR3/LLR4	ZOOLOGY	STA 124		BIO 202
DAY 3	LT1	BIOLOGICAL SCI	CHM 124	BTC 204	
		BIOCHEMISTRY	CHM 124	BTC 204	
		BIOTECHNOLOGY	CHM 124	BTC 204	
		BOTANY	CHM 124	BTC 204	
	OLD CHM LAB/LT2/LLR 5/LLR6	CHEMISTRY	CHM 124	BTC 204	
	LLR3/LLR4/OLD BIO LAB/LT1	COMPUTER SCI	CSC 422	CSC204	
	FLH 1/LLR3/LLR4	GEOLOGY	CHM 124		GEY 406
		INDUSTRIAL CHEM	ICH 124		ICH 244
	LLR6/FLH1/FLH2/LT2	MATHEMATICS	MTH 414		MTH 216
		MICROBIOLOGY			
	LLR1/LLR5	PHYSICS	CHM 124	PHY 228	PHY 452
	LLR3/LLR6/NA5/NA6	STATISTICS	STA 416		
	NA8/9/10/11/12	ZOOLOGY	CHM 124	BTC 204	
DAY 4	LT2	BIOLOGY SCI	PHY 122	BTC 404	
		BIOCHEMISTRY	PHY 122		BCH 242
		BIOTECHNOLOGY	PHY 122	BTC 404	BTC 206
	LT2	BOTANY	PHY 122		BOT 408
	LT1/LT2	CHEMISTRY	PHY 122	CHM 234	CHM 434
	LLR3/LLR4/OLD BIO LAB/COMP LAB	COMPUTER SCI	PHY 122	CSC402	CSC 208
	LT1/LT2	GEOLOGY	PHY 122		GEY 206
		INDUSTRIAL CHEM	PHY 122	ICH 232	ICH 414
	LLR1/MTH LAB/LLR5/OLD BIO LAB	MATHEMATICS	PHY 122		
		MICROBIOLOGY	PHY 122		
	LT1/LT2/FLH 2	PHYSICS	PHY 122	CHM 234	PHY412
	LT1/LLR5/LLR6	STATICTIS	PHY 122		STA 420
	NA7/8/9/10/11/12	ZOOLOGY	PHY 122		
DAY 5	FLH1/FLH2	BIOLOGICAL SCI	BTC 102	ZOO 408	BCH 252
	LLR1/LLR3/LLR4/FLH1&2	BIOCHEMISTRY	BTC 102		BCH 252
	LLR5	BIOTECHNOLOGY	BTC 102	BTC 208	BCH 252
	LLR6	BOTANY	BTC 102	BTC 208	
	LT1	CHEMISTRY	CSC 102	CHM 426	
	LT2	COMPUTER SCI	CSC 102		
	NA7/8/9/10/11/12	GEOLOGY	CSC 102		GEY 210

	COMP/MTH LAB	INDUSTRIAL CHEM	CSC 102	ICH 454	ICH 246
	FLH 1/FLH2	MATHEMATICS	CSC 102		
	NA3/4/5/6	MICROBIOLOGY	MCB 404	MCB 226	BCH 252
	PG CHM/PG PHY LAB/NA3&4	PHYSICS	PHY 422	PHY 214	PHY 418
	NEW BIO LAB 1&2/038/039 UPSTAIR	STATISTICS	CSC 102		STA 422
	LLR3/LLR4//R 1/RM040/041/ 042/043	ZOOLOGY	BTC 102	ZOO 408	BCH 252
DAY 6	LLR5/LLR6/L T2	BIOLOGICAL SCI	BIO 102		BIO 404
	NA10/NA11	BI0CHEMISTRY	BIO 102	PHY 252	
	NA12	BIOTECHNOLOGY	BIO 102		BIO 404
	NA8	BOTANY	BIO 102	BOT 206	BIO 404
	LLR3/LLR4/O LD BIO LAB/LT1	CHEMISTRY	BIO 102	PHY 252	CHM 416
	LT1/LLR3/LL R5/LLR6	COMPUTER SCI			MTH 418
	NA6/LLR1/FL H1/FLH2	GEOLOGY	BIO 102	GEY 408	
	FLH1/LT2	INDUSTRIAL CHEM	BIO 102	ICH 258	ICH 412
	LLR1	MATHEMATICS	MTH 116	MTH 220	MTH 418
	LLR3				
	FLH1/FLH2	MICROBIOLOGY	BIO 102	MCB 222	
	LLR6/NA3/N A4/LT1	PHYSICS	MTH 116	PHY 252	PHY 424
	LLR5/NEW BIO LAB 1&2	STATISTIC	MTH 116	MTH 220	
	LT2	ZOOLOGY	BIO 102		
DAY 7	LLR4/LLR5	BIOLOGICAL SCI	BOT 102		CHM 236
	LLR3/LLR4/L Y1	BIOCHEMISTRY			CHM 236
	LLR4/OLD BIO LAB	BIOTECHNOLOGY	BOT 102		CHM 236
	NA5/NA6	BOTANY	BOT 102		CHM 236
	LT1/LT2	CHEMISTRY	CHM 444	MTH 218	CHM 236
	LT1/LLR1	COMPUTER SCI	CSC 424	MTH 218	
	LT2/OLD CHM LAB/NEW BIO LAB1&2/PG CHM LAB/PG PHY LAB	GEOLOGY	GEY 418		
	OLD CHM LAB/NA1/NA 2	INDUSTRIAL CHEM	BOT 102	MTH 218	ICH 224
	LLR3/FLH2/L T2	MATHEMATICS	MTH 420	MTH 218	

	FLH1/NEW BIO LAB UPSTAIR ROOM 041/042/043	MICROBIOLOGY	MCB 406		CHM 236
	LLR6/LLR1/COMP LAB	PHYSICS	PHY 432	MTH 218	PHY 428
	LLR5/FLH1/FLH2	STATISTICS	STA 236	MTH 218	
	LT2/NA12	ZOOLOGY			CHM 236
DAY 8	LLR3/LLR4/LLR5	BIOLOGY SCI.	BOT 406	BOT 104	BIO 204
	LLR3/FLH1/FHL2/LLR5	BIOCHEMISTRY	MTH 114		
	LT2/LLR1	BIOTECHNOLOGY		MCB 112	
	LLR4/LLR6	BOTANY	BOT 406	BOT 104	BIO 204
	LLR1/COMP LAB/LLR5/LLR6	COMPUTER SCI	MTH 114	STA 212	
	FLH 1/FLH2/LT1/NA1	GEOLOGY	GEY 420	STA 202	BIO 204
	OLD BIO LAB/LTR6/LT2	INDUSTRIAL CHEM	MTH 114		ICH 262
	LT1(NA5/5/7/8)	MATHEMATICS	MTH 114	STA 212	MTH 210
	LT1/(NA5/6/7/8)	MICROBIOLOGY		MCB 112	
	NA3/4/LLR3	PHYSICS	MTH 114	STA 212	PHY 446
	NA11/NA12/LLR1	STATISTICS	MTH 114	STA 202	MTH 210
	NEW BIO LAB UPSTAIRS ROOMS 038/039/040/041/NA6	ZOOLOGY			BIO 204
DAY 9	LT2	BIOLOGICAL SCI.	BOT 404		
	NA3/FLH1/FLH2	BIOCHEMISTRY	MTH 112	STA 222	BCH 214
	NA 4	BIOTECHNOLOGY	MTH 112	STA 222	
	NA 11	BOTANY	BOT 404	BOT 204	
	LT1	CHEMISTRY	MTH 112	CHM 428	
	LLR3/LLR2	COMPUTER SCI.	MTH 112	CSC 408	
	FLH1/FLH2/LT/LR4	GEOLOGY	MTH 112		GEY 202
	OLD CHEM LAB/LLR6	INDUSTRIAL CHEM.	MTH 112	STA 222	
	LLR6/LLR5	MATHEMATICS	MTH 112		MTH 224
	LT1	MICROBIOLOGY	MTH 112		
	LLR1/LLR5	PHYSICS	MTH 112	PHY 458	MTH 224
	OLD BIO LAB/ OLD CHEM LAB/LLR3/NA12	STATISTICS	MTH 112	STA 222	

	NA12/LT2	ZOOLOGY		BOT 204	
DAY 10	LLR1/LT1	BIOLOGICAL SCI.	CHM 224	BOT 402	BTC 212
		BIOCHEMISTRY	CHM 224	PHY 162	BCH 216
		BIOTECHNOLOGY	BTC 408	STA 114	BTC 212
	LT2	BOTANY		BOT 402	
	LT1/LT2	CHEMISTRY	CHEM 224	PHY 162	CHM 424
	LT2/NA6	COMPUTER SCI.	CSC 406	PHY 162	
	LLR3/ LLR4/LLR5/L LR6	GEOLOGY	GEY 410	PHY 162	GEY 208
	NA5/LLR3/FL H1	INDUSTRIAL CHEM.	ICH 214	PHY 162	ICH 436
	LLR5/FLH2	MATHEMATICS	MTH 422		
		MICROBIOLOGY	MCB 412	BOT 402	BTC 212
	LLR5/LLR6/N A4	PHYSICS	PHY 224	PHY 162	PHY 474
	LT1/LLR6/NA 4	STATISTICS	STA 234	STA 114	
	LLR3/LLR4	ZOOLOGY			BTC 212
DAY 11	LT2	BIOLOGICAL SCI.	CHM 162		BIO 408
	OLD BIO LAB	BIOCHEMISTRY	CHM 162	BTC 202	
		BIOTECHNOLOGY	CHM 162	BTC 202	
		BOTANY	CMH 162		
	LT2/FLH1/FL H2	CHEMISTRY	CHM 162	PHY 222	CHM 422
	LT2/LT1	COMPUTER SCI.	CSC432	CSC 212	
	LT1/(NEW BIO LAB UPSTAIRS ROOMS) 038/039/040	GEOLOGY	CHM 162	PHY 222	ICH 430
	FLH1/NA8/N A9	INDUSTRIAL CHEM.	ICH 162	PHY 222	ICH 430
	LLR5/LT1	MATHEMATICS		MTH 214	MTH 118
	NA10/11/12	MICROBIOLOGY	CHM 162	MCB 220	CHM 422
	LLR5/LLR6	PHYSICS	CHM 162	PHY 222	MTH 118
	LLR3/LLR4/L LR1	STATISTICS	STA 426	MTH 214	MTH 118
	LLR2/COMP LAB/LT2	ZOOLOGY	CHM 162		
DAY 12	LT2/FLH1	BIOLOGICAL SCI.	ZOO 412	CHM 134	BIO 402
	LLR3	BIOCHEMISTRY		CHM 134	
	LT2/LLR1	BIOTECHNOLOGY	BTC 214	CHM 134	BIO 402
		BOTANY	BOT 202	CHM 134	BIO 402
	LT1	CHEMISTRY	CSC 202	CHM 134	CHM 412
	LLR5/LLR6	COMPUTER SCI.	CSC 202		MTH 416
	LT1/LT2/NEW BIO LAB1	GEOLOGY	CSC 202		PHY 126
	FLH1/FLH2/L LR3/PHY LAB	INDUSTRIAL CHEM.		ICH 134	1CH 434

	LT1/LT2/NA10/11/12	MATHEMATICS			MTH 416
		MICROBIOLOGY	MCB 408	CHM 134	
	LT2/FLH2/NA7/8/9	PHYSICS	CSC 202	PHY 482	PHY 126
	LT1/LT2/NA4/5/6	STATISTICS	CSC 202	STA 414	STA 116
		ZOOLOGY	ZOO 412	CHM 134	

RESULTS AND DISCUSSION

Federal University Lokoja uses a 3-hour examination period and begins the examination day at 8:00 am and finish at 6:00 pm. The timeslot is 3 (morning, afternoon and evening). The examination takes place within 12 days across thirteen (13) departments.

The chromatic number used to color the thirteen (13) departments are seven (pink, green, lemon, blue, yellow, orange, and purple). The colouring makes no overlapping of courses, thereby creating a system tenable parameter ensures that a student shall not allow for more than 2 examinations per day.

Biochemistry (BCH) is a new department which ends in 200 level.43 venues are allocated to each semester examinations schedule for a particular time. This enables invigilators to appear less for invigilation since the period for examination has been reduced to minimum. A student shall not have a gap of more than 1 day between two consecutive exams. Thus, the schedule is done in the maximum possible timeslot.

CONCLUSSION

Examination timetable scheduling is a peculiar problem to the domicile University. Therefore, no two Universities will have the same examination timetable schedule. The schedule is usually not permanent due to creation of new departments, addition of new courses, removal of obsolete courses and venue or review of curriculum after four (4) years.

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