CIMPA-UNESCO-INDONESIA School
Extremal Problems and Hamiltonicity in Graphs

http://www.maths.web.id/

February 2-13, 2009

Auditorium Campus Center, and
Multimedia Room 9311
Institut Teknologi Bandung
Bandung - Indonesia

FINAL REPORT

Combinatorial Mathematics Research Group
Faculty of Mathematics and Natural Sciences
INSTITUT TEKNOLOGI BANDUNG
2009

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BANDUNG – INDONESIA

1. INTRODUCTION

CIMPA (C*entre* I*nternational de* M*athématiques* P*ures et* A*ppliquées*) is a non-profit international organization established in Nice (France) in 1978. Its aim is to promote international cooperation in higher education and research in mathematics and related subjects, particularly computer science, for the benefit of developing countries.

To do the mission, CIMPA conduct several schools every year in various developing countries. In 2009, CIMPA is conducting 12 schools in Indonesia and Philippines (South East Asia region), Pakistan, Iran and Uzbekistan (India & West Asia region), Guadeloupe-France (Latin America & Caribbean), Burkina Faso and Cameroon (Africa – non Mediterranean), and Egypt, Morocco and Tunisia (Mediterranean). The school on Extremal problems and Hamiltonicity in Graphs was one of these 12 CIMPA schools. This school had a focus in Graph Theory and Its Application; in particular it discussed all the current issues in Extremal Problems and Hamiltonicity in Graphs. The school was conducted by the Combinatorial Mathematics Research Group, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung (ITB), Bandung, Indonesia.

The school was held in Auditorium Campus Center and Multimedia Room 9311, Institut Teknologi Bandung, Bandung, Indonesia, from 2 February until 13 February 2009. As the chairman of the committee, Professor Dr. Edy Tri Baskoro gave an introduction about the school and welcomed all the lecturers and participants. Then, the Rector of ITB, Professor Dr. Djoko Santoso delivered an address and officially opened the school. Professor Michel Jambu as the representative of CIMPA also gave a remark at the opening ceremony.

All lectures in this school were given by six professors (from Australia, Spain, France and Indonesia). The school was attended by 43 graduate students and young researchers from China, Philippines, Jordan, Pakistan, and Indonesia. There were 6 other participants from overseas (India 1, Iran 2 and Pakistan 4) who were not able to come to the school due to various reasons.

The academic program of the school was conducted from 8.30 in the morning until 16.00 in the afternoon, from Monday to Friday. In general there were 6

hours lectures given by 2-3 professors each day. The participants were divided into 8 groups consisting of 5-6 members each, and the groups were assigned to work on small research problems. On the last day, each group presented their results regarding those problems.

The lectures consisted of basic notions of graphs, extremal problems in Moore (di)graphs, graph labeling, Hamiltonian graph theory, extremal graph theory and Ramsey numbers.

In general, the academic atmosphere of the school was great. Both professors and participants were enthusiastic and excited. The interaction between the lecturers and the students was very closed and enjoyable. The discussion occurred in as well as outside the class.

2. AIM and SCOPE OF THE SCHOOL

The aim of the CIMPA-UNESCO-INDONESIA School is to train graduate students as well as young researchers in research activity in several areas of Extremal Graph Theory and Combinatorics. The topics include areas which are currently very active and the School intends to initiate the students and young researchers in research by proposing them Research Projects under the supervision of senior researchers involved in the School.

After an Introductory course in Graph Theory, the school gave courses in Dense Graphs and its applications to the design and analysis of communication networks; on Graph Labeling the school showed some recent techniques from algebra and number theory, and discussed applications in wireless communications, fractal decompositions of networks and optimal networks; on Hamiltonian Graphs the school discussed recent developments on closure techniques and applications to listing combinatorial objects; on Extremal Graph Theory the school presented recent developments related to the Szemeredi Theorem and with applications to coding theory, computer science and optimization and finally on Ramsey Theory the school focused on the estimation of Ramsey numbers and discussing applications to information theory and computer science.

This school consisted of six mini-courses:

1. **Basic notions in graphs, by Joe Ryan (University of Newcastle, Australia)**
2. **Extremal problems in Moore (di)graphs, by Mirka Miller (University of Newcastle, Australia)**
3. **Graph labelings, by Oriol Serra (Universitat Politecnica de Catalunya, Spain)**
4. **Hamiltonian graph theory, by Evelyne Flandrin (Paris-Sud Univ and Paris Descartes Univ, France),**
5. **Extremal graph theory, by Anna Llado (Universitat Politecnica de Catalunya, Spain)**
6. **Ramsey numbers, by Edy Tri Baskoro (Institut Teknologi Bandung, Indonesia)**

Note that: in the original plan, Hamiltonian graph theory would be delivered by Professor Zdenek Ryjacek (University of West Bohemia Czech

Republic). However, due to health problem, he was not able to attend the school. Therefore, his lectures were replaced by Prof. Evelyne Flandrin (Paris-Sud Univ and Paris Descartes Univ, France).

3. DIRECTORS, COMMITTEES, and LECTURERS

The scientific directors of this school were:

- **Professor Mirka Miller**
  University of Newcastle, Australia
  mirka.miller@newcastle.edu.au, and
  University of West Bohemia,Pilsen, Czech Republic.

- **Professor Oriol Serra**
  Universitat Politecnica de Catalunya, Barcelona, Spain
  oserra@ma4.upc.edu

Co-chairs of the organizing committee consisted of the following members:

- **Professor Edy Tri Baskoro (ebaskoro@math.itb.ac.id, ITB, Indonesia)**
- **Professor Joe Ryan (joe.ryan@ballarat.edu.au, University of Newcastle, Australia)**
- **Dr. Hilda Assiyatun (hilda@math.itb.ac.id, ITB, Indonesia)**

This school was given by six professors: two from Australia, two from Spain, one from France and one from Indonesia. They were as follows.

1. **Professor Mirka Miller (Mirka.Miller@newcastle.edu.au), School of Electrical Engineering and Computer Science, University of Newcastle, Callaghan, Australia 2308, and Department of Mathematics, University of West Bohemia,Pilsen, Czech Republic**
2. **Professor Oriol Serra (oserra@ma4.upc.edu), Dept. of Applied Mathematics IV, Polytechnic University of Catalonia, Barcelona, Spain**
3. **Professor Evelyne Flandrin (Evelyne.Flandrin@lri.fr) , L.R.I.- Bat 490 Université Paris-Sud, 91405 Orsay-Cedex, France, and Paris Descartes Univ, France**
4. **Professor Joe Ryan (joe.ryan@ballarat.edu.au), School of Electrical Engineering and Computer Science, University of Newcastle, Callaghan, Australia 2308**
5. **Professor Anna Llado (allado@ma4.upc.es), Departament de Matem`atika Aplicada IV, Universitat Politecnica de Catalunya, Barcelona, Spain**
6. **Professor Edy Tri Baskoro (ebaskoro@math.itb.ac.id), Combinatorial Mathematics Research Group, Faculty of Mathematics and Natural Sciences, Institut Teknologi Bandung (ITB), Indonesia**

All the professors have had important contributions in these areas of research, and they have an extensive teaching experience.

4. PARTICIPANTS

The school was attended by 43 participants with the composition of 19 young researchers, 17 PhD students and 7 master students. They are come from China (1 person), Philippines (2 persons), Jordan (1 person), Pakistan (7 persons), and Indonesia (32 persons). There were 6 other overseas participants funded by CIMPA (India 1, Iran 2 and Pakistan 4) who not able to come to the school due to various reasons. In particular, the participant from Indonesia consists of 11 PhD students and 6 master students from Institut Teknologi Bandung (ITB) and 15 lecturers from various universities, namely:

- **Institut Pertanian Bogor (1 person),**
- **University of Indonesia, Jakarta (2 persons),**
- **University of Padjajaran, Bandung (1 person),**
- **Politeknik Ciwaruga Bandung (1 person),**
- **University of Jember (3 persons),**
- **University of Merdeka, Malang (1 person),**
- **University of Sebelas Maret, Solo (1 person), and**
- **Institut Teknologi Bandung (5 persons).**

The complete list of the participants is presented in the following table.

NO	NAME	SEX	NATIONALITY	STATUS	INSTITUTION
1.	Tianxin Cai	M	China	Professor	Dept of Mathematics, Zhejiang University, Hangzhou
2.	Mohammed Al-Weshah	M	Jordan	Lecturer	Dept of Information Technology, Al-Balga Applied University, Salt.
3.	Ali Ahmad	M	Pakistan	PhD Student	Abdus Salam School of Mathematical Sciences, GC University, Lahore
4.	Muhammad Kashif	M	Pakistan	Master Student	Dept of Mathematics, National University of Computer and Emerging Sciences
5.	Abdul Qudair	M	Pakistan	PhD	Abdus Salam School of

	Baiq			**Student**	**Mathematical Sciences, GC University, Lahore**
6.	**Syed Ahtsham-ul-Haq**	**M**	**Pakistan**	**PhD Student**	**Abdus Salam School of Mathematical Sciences, GC University, Lahore**
7.	**Ahmad Mahmood Qureshi**	**M**	**Pakistan**	**Lecturer**	**Dept of Mathematics, National University of Computer and Emerging Sciences**
8.	**Shabnam Malik**	**F**	**Pakistan**	**PhD Student**	**Abdus Salam School of Mathematical Sciences, GC University, Lahore**
9.	**Fozia Bashir**	**F**	**Pakistan**	**PhD Student**	**Abdus Salam School of Mathematical Sciences, GC University, Lahore**
10.	**Ian June Garces**	**M**	**Philippines**	**Lecturer**	**Dept of Mathematics, Ateneo de Manila University, School of Science and Engineering, Quezon City**
11.	**Jake Albia**	**M**	**Philippines**	**PhD Student**	**Dept of Mathematics, Ateneo de Manila University, School of Science and Engineering, Quezon City**
12.	**Syafrizal Sy**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
13.	**Nurdin**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
14.	**Lyra Yulianti**	**F**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**

15.	**Hazrul Iswadi**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
16.	**Tita Khalis Maryati**	**F**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
17.	**Suhadi Widosaputro**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
18.	**Darmaji**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
19.	**Adiwijaya**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
20.	**I Wayan Sudarsana**	**M**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
21.	**Nur Inayah**	**F**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
22.	**Asmiati**	**F**	**Indonesia**	**PhD Student**	**Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung**
23.	**Yudi Setiawan**	**M**	**Indonesia**	**Master Student**	**Mathematics Graduate Program, FMIPA Institut Teknologi Bandung**
24.	**Herolistra Baskoroputro**	**M**	**Indonesia**	**Master Student**	**Mathematics Graduate Program, FMIPA Institut Teknologi**

					Bandung
25.	Wenny Fitria	F	Indonesia	Master Student	Mathematics Graduate Program, FMIPA Institut Teknologi Bandung
26.	Saefudin Zuchri	M	Indonesia	Master Student	Mathematics Graduate Program, FMIPA Institut Teknologi Bandung
27.	Teduh Wulandari Mediarto	F	Indonesia	Lecturer	Dept of Mathematics, FMIPA Bogor Agricultural University
28.	Denny Riama Silaban	F	Indonesia	Lecturer	Dept of Mathematics, University of Indonesia
29.	Bong Novi Herawati	F	Indonesia	Lecturer	Dept of Mathematics, University of Indonesia
30.	Nurjannah Syahrani	F	Indonesia	Lecturer	Politeknik Ciwaruga Bandung, Indonesia
31.	Hilda Assiyatun	F	Indonesia	Lecturer	Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung
32.	Saladin Uttunggadewa	M	Indonesia	Lecturer	Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung
33.	M. Salman A.N.	M	Indonesia	Lecturer	Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung
34.	Rinovia Simanjuntak	F	Indonesia	Lecturer	Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung
35.	Djoko Suprijanto	M	Indonesia	Lecturer	Combinatorial Mathematics Research Group, FMIPA Institut Teknologi Bandung
36.	Dafik	M	Indonesia	Lecturer	Jember University,

					Jember
37.	Slamin	M	Indonesia	Lecturer	Jember University, Jember
38.	A.A.G. Ngurah	M	Indonesia	Lecturer	Merdeka Malang University
39.	Kristiana Wijaya	F	Indonesia	Lecturer	Jember University, Jember
40.	Daud Lawa	M	Indonesia	Master Student	Mathematics Graduate Program, FMIPA Institut Teknologi Bandung
41.	Mania Roswitha	F	Indonesia	Lecturer	Universitas Sebelas Maret, Solo
42.	Devi Teja Akbari	F	Indonesia	Master Student	Mathematics Graduate Program, FMIPA Institut Teknologi Bandung
43.	Akmal	M	Indonesia	Lecturer	Padjajaran University, Bandung

There were seven participants of the school funded by the CIMPA. The list can be seen as follows.

NO	NAME	SEX	COUNTRY	STATUS
1.	Mohammed Al-Weshah	M	JORDAN	Lecturer
2.	Muhammad Kashif	M	PAKISTAN	Student
3.	Syed Ahtsham-Ul-Haq	M	PAKISTAN	Student
4.	Ahmad Mahmood Qureshi	M	PAKISTAN	Lecturer
5.	Shabnam Malik	F	PAKISTAN	Student
6.	Fozia Bashir	F	PAKISTAN	Student
7.	Ian June Garces	M	PHILIPPINES	Associate professor
8.	Jake Albia	M	PHILIPPINES	Student

There were five participants of the school funded by the ICTP. The list can be seen as follows.

NO	NAME	COUNTRY
1.	Ali Ahmad	PAKISTAN
2.	Abdul Qudair Baig	PAKISTAN
3.	Ian June Garces	PHILIPPINES
4.	Jake Albia	PHILIPPINES
5	Cai Tianxin	CHINA

5. PROGRAMS

The academic program of the school was conducted from 8.30 in the morning until 16.00 in the afternoon, every day. In general there were 6 hours lectures a day, given by 2-3 professors. The participants were divided into 8 groups, each has 5-6 members, and the groups were assigned to solve problems. In the last day, each group presented their results regarding those problems.

The lectures consists of basic notions of graphs, extremal problems in Moore (di)graphs, graph labelings, Hamiltonian graph theory, extremal graph theory and Ramsey numbers. The contents of the lectures are given as follows.

- **BASIC NOTIONS ON GRAPHS BY Joe Ryan**

  This lecture gives the fundamental elements and concepts of graph theory. The School assumes no prior knowledge of Graph Theory. The topics that are covered by this lecture include:

  a) **Introduction to the Theory of Graphs. History and Overview, Elements of Graphs and Digraphs, Applications of Graphs and Digraphs.**
  b) **Walks, Paths and Cycles. Euler Trails, Walks and Paths, Complete Graphs and Complete Bipartite Graphs, Hamiltonian Paths and Cycles, Weighted Graphs and Shortest Paths.**
  c) **Trees. Properties of Trees, Spanning Trees, Applications of Trees.**
  d) **Distance Properties of Graphs. Centre and Periphery, Eccentricity, Applications in Communication Networks, Small World Networks.**
  e) **Connectivity. Cuts, Edge Connectivity, k-connectivity, Connectivity in Digraphs.**
  f) **Graph Colouring. Edge Colouring, Tournaments, Vertex Colouring, Scheduling.**
  g) **Planarity. Plane and Planar Graphs, Euler's Theorem, Maps and Planarity.**
  h) **Matrices. Adjacency Matrices, Eigenvalues in Graphs, Spectral Analysis**

- **EXTREMAL PROBLEMS IN MOORE (DI)GRAPHS BY Mirka Miller**

The principal objective of this, the second of five mini-courses, is to introduce all participants to one of the important unsolved problems in Graph Theory, the degree/diameter problem, also referred to as the N(d,k) problem, or the (d,k) problem. Building on the fundamental elements and concepts presented in the first mini-course, we expect to cover this problem area in a reasonable depth and to give the students an up-to-date knowledge, as well as to introduce them to the intricacies present in this research area.

The list of topics presented below is an approximate plan for the mini-course.

a) **Introduction to the Degree/Diameter Problem. History and overview, Basic terminology, Examples of extremal graphs and digraphs.**
b) **Undirected Moore graphs. Characterization of Moore Graphs, Proof of the Non-existence of Moore Graphs for Most Values of the Parameters, Open Problems**
c) **Undirected Graphs Close to Moore Bound. Regularity of Undirected Graphs Close to Moore Bound, Graphs with Defect 1, Graphs with Defect 2 and More, Open Problems**
d) **Large Undirected Graphs. Construction Methods, Table of Largest Known Graphs, Open Problems**
e) **Directed Moore Graphs. Complete Characterisation of Moore Digraphs, Proof of the Non-existence of Moore Digraphs for Maximum Out-degree and Diameter Greater than 1, and Open Problems.**
f) **Directed Graphs Close to Moore Bound. Digraphs with Defect 1, Diregularity of Almost Moore Digraphs, Digraphs with Defect 2 and More, Open Problems.**
g) **Large Directed Graphs. Construction Methods, Upper and Lower Bounds, Graphs and Digraphs with Relaxed Parameters, Open Problems.**

- **GRAPHS LABELINGS BY Oriol Serra**

The area of graph labeling is an active area of research in graph theory with hundreds of references in the literature. The main problem is to assign a set of integers or the elements of a group to elements of the

graph (vertices, edges or both) such that some arithmetic properties hold. One of the motivations is to address long—standing conjectures on decompositions of graphs, like the celebrated Ringel conjecture on the decomposition of the complete graph by isomorphic copies of a given tree. However the area of graph labelings has many applications both within mathematics and to several areas of computer science and communication networks. The course was to cover the main results in the area and discuss several of its applications.

a. **Decomposition of complete graphs. The Ringel--Kotzig conjecture and graceful labelings. Rosa's four classes of labelings. Basic results on graceful labelings.**

b. **Decomposition of complete bipartite graphs. The Haggkvist conjecture. Bigraceful labelings. Classes of bigraceful trees.**

c. **General and approximated results on graceful and bigraceful labelings. Every tree is a large subtree of a bigraceful tree. Every tree is homomorphic to a graceful tree. Trees with even degrees. Trees with large growth.**

d. **The polynomial method. Trees with large growth. Results on the number of (bi)graceful labelings. Decomposing the complete bipartite graph minus a matching.**

e. **Magic graphs. Basic definitions and results. Sidon sets and weak Sidon sets. Largest cliques in magic graphs. Labelings with pairwise distinct edge--values.**

f. **H-magic graphs. Basic definitions and results. Covering by paths, cycles and stars. Equipartitions of integer intervals. Face magic graphs. Relation with other decomposition problems.**

g. **Related labeling problems and their connections. Applications to communication networks and to computer science.**

- **HAMILTONIAN GRAPH THEORY BY Evelyne Flandrin**

This course covered the main results in the area and discussed several of its open problems:

a. **Basic concepts. Cycles and paths in graphs, Hamiltonian graphs, NP-completeness of the Hamiltonian problem.**
b. **Basic techniques. Degree conditions and longest cycle techniques, Toughness and the Chvátal's conjecture, Closure techniques (based on vertex degrees (Bondy-Chvátal's closure and k-stability, stronger closures, based on structural conditions).**
c. **Strong Hamiltonian properties. Pancyclicity, Hamilton connectedness, cycle extendability.**
d. **Relaxations of hamiltonicity. Traceability, prism-hamiltonicity, 2-factor with limited number of components, spanning k-walk, k-trestle.**
e. **Hamiltonicity in special classes of graphs. Squares, classes of graphs defined in terms of pairs of forbidden subgraphs, line graphs and claw-free graphs, closure and contraction techniques for claw-free graphs and line graphs.**
f. **Some open problems and conjectures.**

- **EXTREMAL GRAPH THEORY BY Anna Llado**

The general problem of classical extremal graph theory asks for the maximum number of edges a graph can have if it does not contain a given graph as a subgraph. The first result in the area is the Theorem of Turán which address the problem for graphs not containing a complete graph of a given order. One of the major results are the Erdös-Simonovits and the Erdös-Stone theorems which relates extremal problems for a familiy of avoided graphs to their chromatic number.

The course contained also applications of extremal problems to the theory and algorithms of combinatorial group testing. Group testing arises in large--scale blood testing for viruses such as HIV, in connection with mapping of genomes or the identification of defective products. Some of these applications will be discussed in the course.

a) **The Turán theorem and the Turán graphs.**
b) **Extremal problems for cycles, paths and trees.**

c) **Extremal roblems for multipartite complete graphs: the Erdös-Stone theorem.**
d) **Chromatic partitions and closeness to the Turán graph. The Erdös-Simonovits theorem.**
e) **The Removal Lemma. The Szemerédi Regularity Lemma.**
f) **Removal Lemma and group testing: applications to experimental designs and to coding theory.**

- **RAMSEY NUMBERS BY Edy Tri Baskoro**

Ramsey theory was introduced in the context of the problem of finding a regular procedure to determine the consistency of any given logical formula (1928). The aim of the study was to give a decision procedure for the sentences of propositional logic. The Ramsey theory became famous after Paul Erdos and George Szekeres (1935) applied it in graph theory. In graph theory, the 'classical' Ramsey number is defined basically the following. For any positive integers m and n, the classical Ramsey number is defined as the smallest integer $R = R(m, n)$ such that every graph F on R vertices will satisfy the following condition: either F contains a complete graph K_m on m vertices as a subgraph or the complement of F has a complete graph K_n on n vertices as a subgraph.

The research on finding the exact values of classical Ramsey numbers $R(m,n)$ has received a lot of attention. However, the results are still far from satisfactory. Since firstly introduced, there are only nine exact Ramsey numbers known so far. In general, determining the exact values of Ramsey numbers is a difficult problem. However, some 'non-trivial' lower and upper bounds for these numbers have been obtained.

Classical Ramsey number has been generalized in various ways, for instance *graph Ramsey numbers* by releasing the completeness in the prescribed conditions, *size Ramsey number*s by considering the minimal size of the graph rather than the order, and in some other types of generalizations.

This course covered the main results and open problems in these various types of Ramsey numbers and Ramsey-minimal graphs. The list of topics is as follows:

a. **Classical Ramsey numbers. Upper and lower bounds. Schur number, Van der Waerden number, and its relations to Ramsey numbers.**
b. **Graph Ramsey numbers. Chvatal-Harary bound, Recent developments on graph Ramsey numbers for various combination of graphs.**
c. **Size Ramsey numbers. 0-sequence and size Ramsey number for join graphs, Size Ramsey for Paths, Size Ramsey for various combinations of graphs.**
d. **Ramsey-minimal graphs. Introduction, (*G*,*H*)-Ramsey minimal graph for various combinations of *G* and *H*.**
e. **Open problems related to Ramsey numbers.**

Daily Schedule of the School

Monday, 2 February, at Campus Center		
Time	**Program**	**Speakers**
08.30 - 09.00	**Opening Ceremony & Introduction**	**-**
09.00 - 09.30	**Break**	
09.30 - 12.00	**Lecture 0**	**Joe Ryan**
12.00 - 13.00	**Lunch**	
13.00 - 14.00	**Lecture 1**	**Joe Ryan**
14.00 - 16.00	**Lecture 2**	**Mirka**

Tuesday, 3 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	**Lecture 3**	**Joe Ryan**
10.30 - 11.00	**Coffee break**	
11.00 - 13.00	**Lecture 4**	**Mirka**
13.00 - 14.00	**Lunch**	
14.00 - 16.00	**Lecture 5**	**Mirka**

Wednesday, 4 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	**Lecture 6**	**Joe Ryan**
10.30 - 11.00	**Coffee break**	
11.00 - 13.00	**Lecture 7**	**Mirka**
13.00 - 14.00	**Lunch**	
14.00 - 16.00	**Lecture 8**	**Mirka**

Thursday, 5 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 9	Joe Ryan
10.30 - 11.00	Coffee break	
11.00 - 13.00	Lecture 10	Evelyne
13.00 - 14.00	Lunch	
14.00 - 16.00	Lecture 11	Evelyne

Friday, 6 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 12	Evelyne
10.30 - 11.00	Coffee break	
11.00 - 11.30	Lecture 13a	Oriol Serra
11.30 - 13.00	Lunch	
13.00 - 14.00	Lecture 13b	Oriol Serra
14.00 - 16.00	Lecture 14	Evelyne
19.00 - 21.00	School Dinner & Cultural Nights	

Saturday, 7 February : One-day Tour , starts 08.30 until 17.00

Monday, 9 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 15	Evelyne
10.30 - 11.00	Coffee break	
11.00 - 13.00	Lecture 16	Anna Llado
13.00 - 14.00	Lunch	
14.00 - 16.00	Lecture 17	Anna Llado

Tuesday, 10 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 18	Oriol Serra
10.30 - 11.00	Coffee break	
11.00 - 13.00	Lecture 19	Oriol Serra
13.00 - 14.00	Lunch	
14.00 - 16.00	Lecture 20	Anna Llado

Wednesday, 11 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 21	Anna Llado
10.30 - 11.00	Coffee break	
11.00 - 13.00	Lecture 22	Oriol Serra
13.00 - 14.00	Lunch	
14.00 - 16.00	Lecture 23	Edy Tri Baskoro

Thursday, 12 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 24	Edy Tri Baskoro
10.30 - 11.00	Coffee break	
11.00 - 13.00	Lecture 25	Oriol Serra
13.00 - 14.00	Lunch	
14.00 - 16.00	Lecture 26	Edy Tri Baskoro

Friday, 13 February, at Multimedia Room 9311		
Time	**Program**	**Speakers**
08.30 - 10.30	Lecture 27	Presentation
10.30 - 11.00	Coffee break	
11.00 - 11.30	Lecture 28	Conclusion
11.30 - 13.00	Lunch	

6. IMPACT

The school drew attention to very active areas of research in Graph Theory. The school gave a strong foundation on graph theory as well as trained the students and young researchers to start doing research in some particular topic in Extremal Problem and/or Hamiltonicity. Lectures were given by first introducing basic and necessary concepts and then discuss the recent development on each topic. Fundamental theorems and recent results were discussed, followed by open problems and conjectures. Some small open problems were offered to the participants to work on. As the results, some of the problems were partially solved. We believe that the two-week training in this school can stimulate the participants to build their research ability and their culture in research. The participants gained a lot of knowledge and methods as well as current development on these topics from the school.

This school, we believe, was able to improve the quality of our graduate programs (master as well as PhD programs). This is because of the involvement of master and PhD students in this school. This school facilitated an opportunity to meet famous and outstanding speakers/researchers in the world. This opportunity is very rare and expensive to happen in Indonesia. The local researchers also got great benefit from the meeting with such well-known people and sharing knowledge of recent developments in Graph Theory. This opportunity is very likely to induce further and new directions of research. Several natural new linkages and cooperation have also occurred. This is also one of the benefits from this school.

7. ACKNOWLEDGEMENT

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