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C O M B I N A T O R I C S

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General Announcements

Under this heading we publish short news items for the information of members. All contributions should be sent to Professor R.W. Robinson, Department of Mathematics, University of Newcastle, N.S.W. 2308, Australia.

NEW ADDRESS :

Alan Harman, Department of Combinatorics and Optimization, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada.

COMINATORICS CONFERENCES :

The Third Caribbean Conference in Combinatorics and Computing, 5-8 January 1981, Cave Hill campus of University of West Indies, Barbados. Invited speakers include Prof. R.C. Read and Prof. Churchhouse. Contact Prof. C.C. Cadogan, Department of Mathematics, University of West Indies, P.O. Box 64, Bridgetown, Barbados, West Indies.

The Twelfth Southeastern Conference on Combinatorics, Graph Theory, and Computing will be held in Baton Rouge, Louisiana, U.S.A. at Louisiana State University, March 2-5, 1981. Contact Prof. K.B. Reid, Department of Mathematics, L.S.U., Baton Rouge, Louisiana, 70803, U.S.A.

Convexity and Graph Theory Conference, 16-19 March 1981, Haifa (16-17) Beer Sheva (18-19), Israel. Contact Prof. Mosche Rosenfeld, Department of Mathematics, Ben Gurion University of the Negev, P.O. Box 653, Beer Sheva 84120, Israel; or Prof. Joseph Zaks, Department of Mathematics, University of Haifa, Mount Carmel, Haifa 31999, Israel.

The Sixth Hungarian Colloquium on Combinatorics, Finite and Infinite Sets, Budapest, Hungary, 6-11 July 1981. Conducted by Janos Bolyai Mathematical Society. Proceedings will be published. Contact E. Gyori, Secretary Cominatorics, J. Bolyai Mathematical Society, H-1368 Budapest, Pf.240., Hungary.

The Eighth British Combinatorial Conference, 20-24 July 1981, Swansea. Contact Prof. H.N.V. Temperley, Department of Applied Mathematics, University College, Swansea SA2 8PP, Wales.

The Ninth Australian Conference on Combinatorial Mathematics, 23-28 August 1981, Brisbane, Queensland. Accommodation in Union College. Contact Dr. Sheila Williams, Dept. of Mathematics, University of Queensland, St. Lucia, Queensland 4067, Australia.

CORRECTION :

From Derek Holton :

The James Joyce mentioned in the report on the Kalamazoo conference in *Combinatorics* Vol.2, No.2 is not "a grandson of the J.J." but is the unique great-grandnephew of the original James Joyce! (Thanks Frank.)

NEW COMBINATORICS JOURNALS :

European Journal of Combinatorics, published quarterly by Academic Press, edited by M. Deza, M. Las Vergnas, P. Rosenstiehl. Editorial correspondence : Journal Europeen de Combinatorie, 54 Boulevard Raspail, 75006 Paris, France.

Combinatorica, published quarterly by North-Holland. Information from Executive Editor : L. Babai, Mathematical Institute of the Hungarian Academy of Sciences, Realtanoda u.13-15, H-1053 Budapest, Hungary.

SIAM Journal on Algebraic and Discrete Methods (SIAD). Information from Managing Editor : D.J. Kleitman, Dept. of Mathematics, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139, U.S.A.

SKOLEM PARTITIONS :

From Douglas G. Rogers, Dept. of Mathematics, University of Kansas, Lawrence, Kansas 66045, U.S.A.

"I am compiling a survey of *Skolem partitions* (for definition and references, see below), their generalizations and applications. I should much appreciate any information (including copies of research reports where available) which you can supply on this topic, especially regarding the occurrence of these and related partitions in your own work. I shall, of course, be happy to acknowledge your assistance and to send you a copy of the survey when it is completed."

DEFINITION : A *Skolem partition* of the set $S = \{1,\ldots,2m\}$ is a family of sets

$$S_r = \{a_r, b_r\},\ 1 \leq r \leq m, \quad \text{such that}$$

$$\text{(i)} \quad \bigcup_{r=1}^{m} S_r = S ;$$

$$\text{(ii)} \quad b_r - a_r = r,\ 1 \leq r \leq m.$$

REFERENCES :

1. Th. Skolem, "On certain distributions of integers in pairs with given differences", *Math. Scand.*, 5(1957), 57-68.

2. Th. Skolem, "Some remarks on the triple systems of Steiner", *Math. Scand.*, 6(1958), 273-280, esp. 274.

CHINESE COMBINATORICISTS :

Derek Holton (Dept. of Mathematics, University of Melbourne, Parkville, Victoria 3052, Australia) is trying to organise a visit to Australia in July-August 1981 by two Chinese combinatoricists, Liu Chen-hung and Chu Yoeng-Chin. Tell Derek in the next few weeks if you are interested in having them visit your department and if so for how long, and whether you can (or hope to be able to) provide financial support. Curriculum vitaes and other information is available from Derek.

TEMPORARY ADDRESS :

Brian Alspach. Until 20 November 80 : Dept. of Maths., Pennsylvania State University, University Park, Pennsylvania 16802, U.S.A.
For Decemeber 1980 : c/- Dr. K.B. Reid, Dept. of Maths., Louisiana State University, Baton Rouge, Louisiana 70803, U.S.A.
For Jan-April 1981 : Dept. of Maths., Ben Gurion University of the Negev, Beer Sheva, Israel.

Higher Degrees

Supervisors of higher degree theses on combinatorial mathematics in Australasian institutions are invited to send details - recipient's name, supervisor's name, degree, date awarded, institution, title, abstract - to Dr. Shiela Williams, Dept. of Mathematics, University of Queensland, St. Lucia, Queensland 4067, Australia.

Previous lists appeared in *Combinatorics* Vol.1, No.2, and Vol.2, No.2.

	Student Degree Date Awarded	Supervisor Institution	Title Abstract reference
1.	CHIDZEY, Keith G. M.Sc. 1977	D.A. Holton U. of Melbourne	Fixing subgraphs and smoothly embeddable subgraphs
2.	GODSIL, Christopher D. Ph.D. 1979	D.A. Holton U. of Melbourne	Graphs with regular groups
3.	HAIR, Richard Martin M.Sc. 1977	L.G. Kovacs J.S. Wallis A.N.U.	Circulant weighing matrices
4.	HEINRICH, Katherine Anne Ph.D. 1979	W.D. Wallis U. of Newcastle	Some problems on combinatorial arrays
5.	MILAS, J. M. Math. 1979	W.D. Wallis U. of Newcastle	Hadamard matrix construction by difference methods
6.	RUSSELL, Kenneth R. Ph.D. 1977	J.A. Eccleston U. of N.S.W.	On the theory of row-column designs Bull.Austral.Math.Soc. 17(1977) 149-150
7.	SCOTT, Trevor B. M.Math. 1977	W.D. Wallis U. of Newcastle	School timetabling algorithms

ABSTRACTS :

K.G. Chidzey, Fixing subgraphs and smoothly embeddable subgroups.

An error in a theorem of Grant which connects the two concepts of the thesis is noted and corrected.

The fixing subgraphs of $K_{m,n}$ are investigated. Specifically it is found that (1) if H is a connected minimal fixing subgraph of $K_{m,n}$ then H is a path of odd size and $|m - n| = 1$ and (2) given any T with unequal parts, there is a complete bipartite graph which has a minimal fixing subgraph which contains T as a component.

A list of twelve unsolved problems is included as the last chapter.

C.D. Godsil, Graphs with regular groups.

We show that if G is a finitely generated group which is neither abelian nor generalized dicyclic then either it has a GRR or it is one of 13 exceptional groups with order at most 32. (A group G is generalized dicyclic if it is non-abelian and has an abelian normal subgroup A of index two and an element x of order four in G\A such that for each $a \in A$, $x^{-1}ax = a^{-1}$. A graph X is a GRR for a group G if its automorphism group is isomorphic to G and acts regularly on the vertices of X.)

This settles in the affirmative Mark Watkins' conjecture that sufficiently large finite non-abelian, non generalized dicyclic groups have GRR's and that those finite groups without GRR's are characterized by the property that any generating set is fixed by some non-trivial group automorphism.

R.M. Hair, Circulant weighing matrices.

Circulant weighing matrices are matrices with entries in {-1, 0, 1} where the rows are pairwise orthogonal and each successive row is obtained from the previous row by a fixed cyclic permutation. They are useful in solving problems where it is necessary to determine as accurately as possible, the "weight" of n "objects"in n "weighings". They have also been successfully used to improve the performance of certain optical instruments such as spectrometers and image scanners.

In this thesis I discuss the basic properties of circulant weighing matrices, prove most of the known existence results known to me at the time of writing this thesis and classify the circulant weighing matrices with precisely four nonzero entries in each row. The problem of classifying all circulant weighing matrices is related to the "cyclic projective plane problem". This relationship is established and I have devoted the final chapter of this thesis to cyclic projective planes and their relationship to circulant weighing matrices. The final theorem in this thesis yields information about equations of the kind $xy^{-2} = a$ in cyclic projective planes.

K.A. Heinrich, Some problems on combinatorial arrays.

Several results (mainly constructive) on Latin squares, equidistant permutation arrays and other arrays are presented.

J. Milas, Hadamard matrix construction by difference methods.

The author surveys the construction of Hadamard matrices by difference methods and gives all other constructions which lead to matrices of order 36. Then equivalence of Hadamard matrices is discussed. Finally a lower bound is obtained for the number of inequivalent Hadamard matrices of order 36.

T.B. Scott, School timetabling algorithms.

The author presents an analysis of school timetable construction and its relationship to graph colouring.

Algorithms are presented in detail.

A Survey of Undergraduate Courses in Combinatorics and Graph Theory Taught in Australia and New Zealand

Prepared by Charles H.C. Little

Continued from *Combinatorics*, Vol.2, No.2.

(6) Monash University

Monash is one of the few institutions to teach a substantial amount of graph theory in first year. The first year subject 711, which is taken by approximately 200 students, contains about 12 lectures on graph theory. Monash also offers a second year course, 221, studied by about 80 students, and two third-year subjects, 7312 and 7351.

711 Introduction to Algebra: introduction to graphs, vertices, edges, loops, vertex degree, edge multiplicity, simple graphs, complement of a simple graph, subgraphs, binary relations and mappings, domain, range, injections, surjections, bijections, inverse of a relation, composition, identity mapping, graph isomorphism, handshaking lemma, regular graphs, equivalence relations and partitions, edge-sequences, paths, arcs, cyclic paths, circuits, connectedness, components, Königsberg bridges, Euler lines, covering paths, algorithm for finding an Euler line, Hamilton lines, trees: equivalent conditions, spanning trees, the minimal connector problem: Kruskal's algorithm. The remainder of the syllabus deals with linear algebra. Assessment: test 20%, exam 80%. Text: Ore.

221 Combinatorial Mathematics: permutations and combinations; generating functions; transversals: Hall's theorem, König-Egerváry theorem; Latin squares: experiment design, error-detecting code theory; graph theory: Menger's theorem. Texts: Hall, Wilson, Knuth.

7312 Combinatorics and Computability: classical combinatorics: Stirling's formula for n!, generating functions, partitions, use of Möbius inversion and Burnside's lemma in enumeration problems; combinatorial operations research: flows in networks, scheduling and discrete optimization problems; finite algebras and geometries: finite groups, fields and planes used to construct Latin squares and error-correcting codes; computational complexity: efficient algorithms for solution or reduction of combinatorial problems; NP-complete problems

in logic, number theory, operations research, coding theory and geometry. Assessment: assignments 30%, 1½ hour exam 70%.

7351 Graph Theory: Euler's theorem, connectivity, blocks, trees, partitions, line graphs, Hamilton graphs. Assessment: assignments and examination.

(7) Royal Melbourne Institute of Technology Ltd.

R.M.I.T. has two courses which are options available to second and third year students. These courses are offered both internally and externally. The time allotted for each course is 2 hours/week for one semester. Internal students are assessed by assignments and tests and external students by assignments and examination.

MA800 Combinatorics: permutations and combinations, binomial theorem, matchings and systems of representatives, assignment problems, recurrence relations, generating functions, Fibonacci sequences, enumeration, inclusion-exclusion principle, block designs, Hadamard matrices, codes, Steiner systems. Text: Anderson.

MA801 Graph Theory: topics chosen from the following list: Eulerian graphs, Hamiltonian graphs, trees, planar graphs, duality, embeddings, colourings, directed graphs, tournaments, Hall's theorem, Menger's theorem, flows in networks, matroids. Text: Wilson.

(8) University of Melbourne

Melbourne offers a third year course in combinatorics to advanced students. This course covers Chapters 1-6 of Anderson. The time allotted is 16 lectures and 8 practice classes.

A fourth year course on graph theory is also offered. This course consists of 8 introductory lectures and approximately 16 seminars. The text is Biggs. Assessment is by means of assignments, research problems and a library exercise.

IV. TASMANIA

University of Tasmania

SMA115Y Discrete Modelling I: introduction to probability, linear programming and difference equations, with applications chiefly to the biological, physical and social sciences. Time allotted: 2 lectures and 1 tutorial/week for 14 weeks. Texts: Anton & Kolman, Goldberg. This is a first-year course.

SMA215W Discrete Modelling II: selected topics from elementary combinatorics including networks, probability, random walks, counting techniques, optimization and game theory, with applications chiefly to the biological, physical and social sciences. Time allotted: 2 lectures and 1 tutorial/week for 13 weeks. This is a second-year course.

SMA304T Geometry: introduction to projective geometries and their collineation groups leading to usual Euclidean geometry. Time allotted: 2 lectures and 1 tutorial/week for 3 terms. This is a third-year course.

SMA315H Discrete Modelling III: selected topics from graphs and networks, Boolean algebra, counting techniques, coding, optimization, stochastic processes, with applications to biological, physical, social sciences and electrical engineering. Time allotted: 3 lectures and 1 tutorial/week for 2 terms. Text: Taha. This is a third-year course.

SMA400A is the fourth-year Honours course. The theory and application of matroids constitutes $\frac{1}{5}$ of the year's load. This is the only undergraduate course on matroids in Australasia.

V. SOUTH AUSTRALIA

(1) Flinders University of South Australia

Flinders offers one second-year course in combinatorics. This course is under revision with a view to placing more emphasis on graph theory.

Combinatorics: permutations and combinations, Stirling's formula, generating functions, recurrence relations, principle of inclusion, theory of graphs, trees, circuits, cut sets, planar and dual graphs, domination, independence, chromatic numbers, four colour problem, max-flow min-cut theorem in networks. Time allotted: 3 lectures and 1 tutorial/week for 1 term.

(2) South Australian Institute of Technology

The first-year course Mathematics ICSB includes 12 hours on graph theory. S.A.I.T. also offers a third-year course on operations research.

Mathematics ICSB: elementary graph properties, walks, paths, circuits Dijkstra's shortest path algorithm, elementary tree properties, spanning trees, elementary circuit matrices, rank, nullity, electrical network applications.

Operations Research: review of elementary graph and directed graph theory; networks; paths, cycles, tours and trees with applications in operations research and computing; flow networks and applications; combinatorially complex problems: polynomial time problems, NP-complete problems. Time allotted: approximately 25 hours.

(3) University of Adelaide

(a) Dept. of Applied Mathematics

The third-year unit Mathematical Programming contains some applied graph theory.

(b) Dept. of Computing

The third-year unit A307 consists of an elementary treatment of graph theory and a consideration of the application of graphs to the critical path method. Extensive computer exercises are included.

(c) Dept. of Pure Mathematics

176 Combinatorics: introduction, combinations, recurrence relations, generating functions, block designs. This is a second-year course.

Combinatorial Geometry: block designs, Hadamard matrices, Latin squares, Room squares, cyclic planes, biplanes, (k; n)-arcs and caps in a Galois space. This is a fourth-year Honours unit.

VI. WESTERN AUSTRALIA

Western Australia apparently imports most of the expertise in combinatorics and graph theory it requires. The University of Western Australia has a second-year half-unit, taken by weaker students, which contains some graph theory, and the third- and fourth-year statistics courses contain some work on experiment design. In view of the relative isolation of Perth, it is surprising that no institution there has seen fit to offer courses with more combinatorics or graph theory content.

VII. NEW ZEALAND

Only two universities in New Zealand offer courses in combinatorics or graph theory.

(1) University of Canterbury

MATH464 Combinatorics: basic counting techniques, generating functions, principle of inclusion and exclusion, partially ordered sets, Möbius inversion, Hall's theorem, sequences with restrictions, simple tiling problems, permanents, determinants, matrix tree theorem, orthogonal Latin squares, finite projective geometries, structures, t-designs, symmetric designs, Bruck-Ryser-Chowla theorem, permutation groups, transitivity, automorphisms of designs, Hall's multiplier theorem, extensions and contractions, residual designs, derived designs.

A fourth-year course called Combinatorial Optimization is also offered. This course covers graphs, networks and applications to problems in operations research such as finding minimal spanning trees, location and layout problems and the travelling salesman problem. The text is Deo.

(2) Massey University

60.406 Applied Graph Theory: theory: basic ideas of graph theory, connectivity, trees, fundamental circuits, cutsets, planarity, graph matrices, digraphs; applications: travelling salesman problem, vehicle scheduling problem, molecular evolution, school bus scheduling, plant layout, flow networks, electrical networks, car pooling. Text: Deo.

APPENDIX

The following is a list of books used as texts in undergraduate courses in combinatorics and graph theory in Australia and New Zealand. They have been referred to above by the author's surname only.

1. Anderson, A First Course in Combinatorial Mathematics, Clarendon, 1974.
2. Andrásfai, Introductory Graph Theory, Hilger, 1977.
3. Anton & Kolman, Applied Finite Mathematics, Academic Press, 1978.
4. Biggs, Algebraic Graph Theory, Cambridge, 1974.
5. Bondy & Murty, Graph Theory with Applications, Macmillan, 1977.
6. Christofides, Graph Theory: An Algorithmic Approach, Academic Press, 1975.
7. Cohen, Basic Techniques of Combinatorial Theory, Wiley, 1978.
8. Deo, Graph Theory With Applications to Engineering and Computer Science, Prentice-Hall, 1974.
9. Goldberg, Introduction to Difference Equations, Wiley, 1958.
10. Goodman & Ratti, Finite Mathematics with Applications (3rd ed.), Macmillan, 1979.
11. Hall, Combinatorial Theory, Wiley, 1967.
12. Knuth, The Art of Computer Programming, Addison-Wesley, 1968.
13. Liu, Introduction to Combinatorial Mathematics, McGraw-Hill, 1968.
14. Ore, Graphs and Their Uses, Singer, 1963.
15. Roberts, Discrete Mathematical Models, Prentice-Hall, 1976.
16. Stone, Discrete Mathematical Structures and their Applications, S.R.A., 1973.
17. Street & Wallis, Combinatorial Theory: An Introduction, Babbage, 1977.
18. Taha, Operations Research, Macmillan, 1976.
19. Wilson, Introduction to Graph Theory, Oliver & Boyd, 1972.

Combinatorial Mathematics Society of Australasia

Minutes of the Second Annual Meeting held on 27 August 1980 at Deakin University, Geelong, Victoria.

OPENED: 1330 hours.

PRESENT: K.L. McAvaney (Chairman), L.R. Foulds (Acting Secretary) and 30 members.

APOLOGIES: Nil.

MINUTES OF FIRST A.G.M.: Confirmed as circulated in *Combinatorics* Vol. 1, No. 5. (A. Hartman /L. Foulds).

BUSINESS ARISING:

1. Venue for 1981 and 1982 conferences. Discussion deferred.

2. Travel subsidy for student participants. One participant of 8ACCM was supported under this scheme.

DIRECTORS REPORT 1980:

1. Notices announcing the existence of CMSA and 8ACCM were placed in the newsletters of approximately 20 mathematics societies throughout the world and sent to approximately 85 institutions throughout Australasia and South-East Asia.

2. There are 86 paid up members of CMSA.

3. *Combinatorics* Vol. 2, Nos. 1 and 2 have been published. Nos. 3 and 4 are expected to be out in October and December respectively.

4. Approximately 20 organisations were approached for donations towards 8ACCM. The following agreed and their generous financial support (total approximately $2700) is gratefully acknowledged: Division of Computing and Mathematics Deakin University, Department of Mathematics RMIT, ANZ Banking Group Ltd., Blue Circle Southern Cement Ltd., Australian Mathematical Society, National Mutual Life Association of Australasia Ltd., The Ian Potter Foundation.

FINANCIAL REPORT 1979:

A statement of receipts and payments up to 31 December 1979 was presented by W.D. Wallis. Report received (A. Hartman /P. Eades).

VENUES FOR 9ACCM AND 10 ACCM:

Agreed that the venue for 9ACCM be the University of Queensland (D.A. Holton/ R. Taylor).

Agreed that the venue for 10ACCM be University of Adelaide (D.A. Holton/W.D. Wallis).

ELECTION OF OFFICERS FOR 1981:

The following were elected:
Director: Sheila Williams (nominated by R. Casse).
Secretary: Elizabeth Billington (nominated by S. Williams).
Treasurer: Peter Eades (nominated by W.D. Wallis).

FEES 1980:

Remain at $4 and $2 (W.D. Wallis/D.A. Holton).

GENERAL BUSINESS

1. Relationship with Australian Mathematical Society.

   The incoming committee is requested to investigate the desirability of a formal link with A.M.S. and report to the next A.G.M. (B. Neumann/C. Little).

2. Life Membership.

   The incoming treasurer is requested to investigate the possibility of a life membership plan for CMSA at a fee of approximately 20-25 times the current subscription (D. Rogers/W.D. Wallis).

CLOSED: 1408 hours.

New Publications

Authors are invited to send details of publications on appearance to Dr. D.A. Holton, Department of Mathematics, University of Melbourne, Parkville, Victoria 3052, Australia.

H.L. Abbott, M. Katchalski and A.C. Liu, An extremal problem in graph theory II, *J. Austral. Math. Soc.*, 29A (1980) 417-424.

P.J. Cameron, 6-transitive graphs, *J. Comb. Th.*, 28B (1980) 168-179.

F. Harary and A. Vince, Graphical completions of a sequence, *Siam J. Appl. Math.*, 38 (1980) 402.

D.G. Johnstone and L.R. Foulds, Chess Piece Placement Puzzles, *N.Z. Math. Mag.* 17 (1980) 12-27.

G. Olive, A combinatorial approach to generalized powers, *J. Math. Anal. Appl.*, 74 (1980) 270-285.

D.J. Street, Bhaskar Rao designs for cyclotomy, *J. Austral. Math. Soc.*, 29A (1980) 425-430.

Research Announcements

Please send contributions to Dr. D.A. Holton, Department of Mathematics, University of Melbourne, Parkville, Victoria 3052, Australia. *An asterisk indicates that preprints of that article are available.*

L.R. Foulds and R.W. Robinson: Determining the Asymptotic Number of Various Classes of Phylogenetic Trees.

L.R. Foulds and P.B. Gibbons: Identifying maximum weight planar subgraphs.

* D.A. Holton: Cycles through specified vertices in k-connected regular graphs.

* R. Taylor: Switchings constrained to 2-connectivity.

7 A.C.C.M. Proceedings

The proceedings of the Seventh Australian Conference on Combinatorial Mathematics (University of Newcastle, 20-24 August 1979) has now been printed.

It is : *Combinatorial Mathematics VII*, ed. Robert W. Robinson, George W. Southern, Walter D. Wallis, Lecture Notes in Mathematics 829, Springer-Verlag, Berlin, Heidelberg, New York, 1980. The contents page appears below. When the free copies arrive at Newcastle (they are now on the way by surface mail and expected to arrive in about a month) they will be sent to all participants and co-authors.

INSTRUCTIONAL LECTURES

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