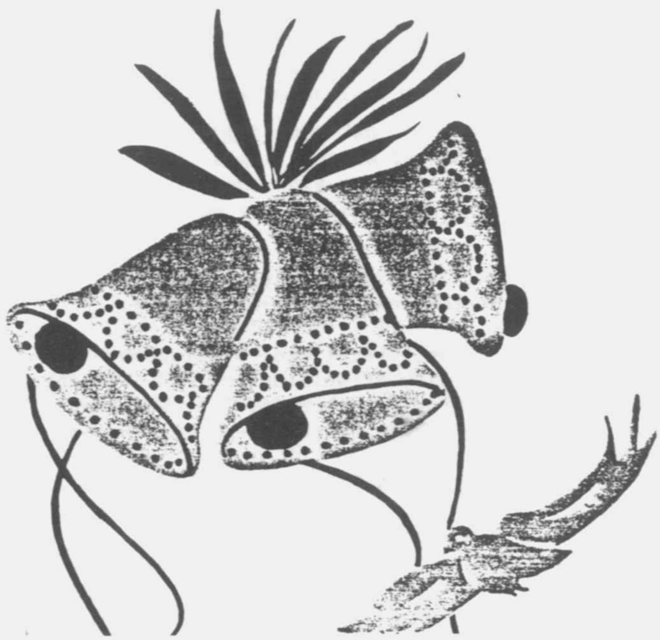
THE NEW ZEALAND MATHEMATICAL SOCIETY

NEWSLETTER



RINGING THE CHANGES

CENTREFOLD
PROFESSOR WILLIAM DAVIDSON

CONTENTS

Number 30 April 1984 ISSN 0110-0025

Editorial

This issue features an article on bellringing by Dr Bennett, who was an invited speaker on this topic at the 11th Australasian Combinatorial Mathematics Conference held at Canterbury University last August. Also Dr Gordon Knight, who recently received his Ph.D. in Education, writes on some of his findings why otherwise able adults have difficulty in understanding mathematics. The centrefold honours the current NZMS President, Professor Bill Davidson, whom we wish well in his retirement next year.

Observant readers will notice that the crossword has shifted from its usual position. Mr Varnish requested that this crossword, coming as it does after No. 12 in the last issue, should be placed on a more appropriate page, especially since one of the clues involves a superstitious fear of that particular page number! The Book Reviews section is now being sub-edited by Dr John Clark of the Mathematics Department at Otago University and any relevant correspondence should be sent directly to him. The Secretarial section contains nominations for the next Council, the election of which will be held at the NZMS Annual General Meeting on May 7 at Victoria University during the 19th Mathematics Colloquium.

Finally a reminder that items of news, notices, articles of general interst, suggestions for centrefolds, letters to the editor on current issues are always welcome and may be sent to the editor or one of the honorary correspondents. Copy date for the next issue is 15 July, 1984.

John Curran
Editor

HONORARY CORRESPONDENTS OF NEWSLETTER

Dr R. Allan	Fisheries Research Division, P.O. Box 293, Wellington.
Dr M.R. Carter	Department of Mathematics and Statistics, Massey University, Palmerston North.
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Dr J. Heath	School of Maths & Science, Wellington Polytechnic, P.B. Wellington.
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Dr M.A. Jorgensen	Biometrics Section, Ministry of Agric. & Fish., P.O. Box 1550, Wellington.
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Mr J.H. Maindonald	D.S.I.R.-A.M.D., Mt Albert Research Centre, Private Bag, Auckland.
Dr S.A. Morris	Australian Mathematical Society, Dept. of Pure Mathematics, La Trobe University, Bundoora, Victoria 3983, Australia.
Mr P.R. Mullins	Dept. of Community Health, University of Auckland, P.B., Auckland.
Dr G. Olive	Mathematics Department, University of Otago, P.O. Box 56, Dunedin.
Mr K. Perrin	Dept. of Maths Education, Teachers College, Secondary Division, P.O. Box 31065, Christchurch 4.
Assoc. Prof. I.L. Reilly	Department of Mathematics and Statistics, University of Auckland, P.B., Auckland.
Dr D.M. Ryan	Theor. & Appl. Mechanics, University of Auckland, P.B., Auckland.
Dr M. Schroder	Mathematics Department, University of Waikato, P.B., Hamilton.
Mr B.R. Stokes	Department of Mathematics, Teachers College, Hamilton.
Mr G.J. Tee	Department of Computer Science, University of Auckland, P.B., Auckland.
Dr G.J. Weir	Applied Mathematics Division, D.S.I.R., P.B., Wellington.

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Local News

AUCKLAND UNIVERSITY

DEPARTMENT OF MATHEMATICS & STATISTICS

Dr Chris Wild has returned after spending terms II and III in England, Canada and U.S.A.

Dr M. Vamanamurthy has now gone on leave and after an initial visit to India, he will be spending 12 months in Michigan, U.S.A.

Dr Ganesh Dixit has been on vacation in India and whilst there attended a Symposium on Mathematical Analysis and its Applications at the Indian Institute of Technology, New Delhi, and the 71st session of the Indian Science Congress. Ganesh is a founder member of the Allahabad Maths Society and a Life Member of the Indian Science Congress Association.

Dr Marston Conder is now at Victoria University and in exchange we have Professor Rob Goldblatt with us for the 1984 academic year.

Dr Nick Wormald has been appointed lecturer and this fills the vacancy which we had in 1983. Nick and his family come from Sydney.

Our new part-time appointees this year are Ian Hawthorn, Noel Wass and Wiremu Solomon, and our departmental visitor is Dr Nye John of the University of Shouthampton. Dr John gave a seminar in the Department last Easter. He will be with us until July of this year.

In December, Professor Jan Jaworowski and his wife Wanda returned to Indiana. During his stay with us Jan taught courses in Linear Algebra and Algebraic Topology. He gave a series of seminars on his recent work on Fibre Preserving Free Involutions and the Borsuk-Ulam theorem. Jan also found time to visit and give seminars at Canterbury and Victoria Universities.

Seminars

Professor Richard D. Anderson (Louisiana State University), *'A Survey of recent developments in Infinite-Dimensional Topology'.*
Stephen Haslett (Institute of Statistics and O.R. Victoria University), *'Updating estimates in Linear Models with correlated errors'.*
Dr Michael Walker (University of Michigan), *'Quasiconformal Mappings and linearly locally connected sets'.*
Professor J.N. Darroch (School of Mathematical Sciences, Flinders University of South Australia). *'Categorical Repeated Measures'.*
Dr Nick Fisher (C.S.I.R.O., Sydney), *'Graphical Methods for Testing Independence'.*

Special Seminar Discussions:

Sharlees Forbes (Victoria University) gave a talk on her "Basic Skills" programme based on modules of written material which she has developed and used over the past two years.

John Turner (Waikato University) gave a talk on a Computer Based Remedial Maths programme which he has been directing in 1983.

I.L.R.

DEPARTMENT OF COMPUTER SCIENCE

At the start of the academic year 754 students had enrolled for courses in Computer Science, with 476 taking 1 or 2 Stage 1 papers.

Rick Mugridge has been appointed a lecturer, after having previously been a Junior Lecturer in the Department. His work has been largely concerned with databases.

Peter Gibbons is on leave at the University of Toronto, for Terms 1 and 2.

Mr Cao Liming, from the China Institute of Mining, Xuzhou, Jiangsu, is a Visitor in our Department for 1984 and 1985. He has worked on fuzzy set theory, and is now studying computer science and assisting with the work of the Department. Before coming to New Zealand, he was taught English by Dr Jock Hoe, at the Foreign Languages Institute in Shanghai.

John Thornley and Philip Welcome have joined the staff, as Assistant Lecturers. John Thornley is completing his M.Sc. in computer science, and Philip Welcome has completed his M.Sc. in Physics.

Karsten Foehlster has joined the Department as a technician.

The Department now has 45 Z89 microprocessors, 3 Apples, 1 LSI-11; and recently 2 PDP-11 computers were donated by Fisher & Paykel Ltd. Consequently, all of our courses now use Departmental computers, with a few advanced courses also making some use of the large main-frame computers in the Computer Centre.

The plans for construction of the additional floor for the Science Library building have now been approved. Initially our Department will use that new floor, and it is hoped that it will be completed in time for the 1985 academic year.

Professor Jan Jaworowski, of Indiana University, was a visiting lecturer in the Department of Mathematics and Statisitcs for the second half of 1983. His wife Wanda is the Principal Violinist in the University of Indiana Orchestra. As a gesture of thanks to the University of Auckland, the members of the Departments of Mathematics and Statistics, of Computer Science and of Music were entertained, on 16 December 1983, by a violin and piano recital performed by Wanda Jaworowski and Elizabeth Boulton. They performed works by Leclair, Brahms, Wieniawski, Penderecki and Bacewicz, in one of the houses of the Music Department. The occasion formed a most agreeable farewell for the Jaworowskis.

G.J.T.

WAIKATO UNIVERSITY

We have just struggled through enrolment. Numbers are up again slightly, except at third year, and we just avoided having to split the largest class, Basic Mathematics (371 into 381 does go). Three overseas travellers are back.

Ernie Kalnins went to Delhi for a week or so, where he gave an invited address at the International Symposium on Mathematical Analysis and its Applications held at the Indian Institute of Technology. "Given the failure of the American contingent to arrive, New Zealand provided some of the significant foreign input, with myself and Ganesh Dixit from Auckland. A very well organised meeting, it indicated there is good work being done on this subject in India."

Kevin Broughan spend four enjoyable weeks during January and February at Berkeley, working as a consultant with a research project in the Centre for Pure and Applied Mathematics. A new symbolic mathematics system is being built, based on the language Newspeak (see 1984, the book). The relationship of Newspeak to Lisp mirrors that of post- to pre-set-theoretic mathematics. The new system (called BAAD, for Berkeley Algebra and Analysis Development) will probably not be as comprehensive as MACSYMA, but it will be less tangled and have better foundations, mathematically. Kevin's own work was done in Lisp, on Naglink, a sophisticated interface between MACSYMA and NAG. "Berkeley attracts a great deal of funding for equipment from the private sector. They will get $10 M of computer equipment as a gift from IBM over the next three years, and five VAX es from DEC in 1984 as well - such largesse we can hardly imagine!"

Ian Craig is back, too. "I spent 8 months (May to December) at Glasgow, mostly collaborating with Dr John C. Brown on astrophysical inversion problems, and on the solution of the electron continuity equation in the description of the solar hard X-ray burst. More noteworthy perhaps was the heat-wave that permitted swimming in Lock Lomond and Loch Drunkie, followed by alcoholic refreshment at the numerous 'spit and sawdust' saloons for which Glasgow is rightly infamous. The Shish Mahal maintained its high rating with us; by some mysterious oversight, it has yet to appear in the Good Food Guide."

He continues, "I went to San Diego for January and February, to collaborate with Drs Sandy McClymont and Dick Canfield. The incomprehensibility of radiative transfer (Dick's raison d'être) was not allowed to mar the visit. Some solar flare work was achieved, despite another heat-wave that pushed temperatures past 25°C - in mid-winter! Jacuzi and swimming pool provide weekend relief for aching desk-bound body."

M.S.

MASSEY UNIVERSITY

Sue Byrne returned recently from 5½ months in the wintered north. The first 4½ months were spent in London, at the Department of Chemical Engineering, Imperial College, where she worked on some programmes for quadratic programming, and did battle with a large, impersonal computer centre. On of their more interesting (?) activities was the attempted but unsuccessful introduction of an entire new operating system in the final week of term! In addition, Sue attended a NAG users meeting in Cambridge, went to seminars in Oxford and Cambridge, and in other parts of Imperial College, met a peripatetic member of Victoria's staff, not at DAIMP, Cambridge as usual but at Imperial College, and otherwise enjoyed a mild clear winter in London. The final month was spent in the U.S.A., visiting Chemical Engineering, Mathematics and Industrial Engineering departments at the Universities of Massachusetts, Anherst, and Carnegie-Mellon, Pittsburgh, Washington, Chicago and Minneapolis. Sue was able to have useful discussions on optimization and techniques for solution of nonlinear equations, particularly in design problems; also on computer packages useful for teaching. Sue's last stop was the Mathematics Department at the University of California, San Diego, where the warmth was a pleasant change after the 0^{o}F outdoor temperatures of the earlier part of the trip.

Susan Nicoll, a recent Massey B.Tech.(Maths) graduate now working at MAF in Wellington, won the 1982 student paper prize of the N.Z. Operational Research Society. Her paper "A Production Planning Model for the Tui Dairy Company" resulted from work supervised by Sue Byrne with the help of Tim Hesketh of Massey's Production Technology Department.

Over the past year some of us have been preparing audio cassettes (and accompanying workbooks) on various topics in elementary algebra. These are mainly intended as revision aids for extramural students. They were made available on loan to students from the beginning of this year, and demand has been gratifyingly high. We intend ultimately to build up an extensive library of these tapes.

Seminars:

Professor Irving Adler, *'A contact pressure model of phyllotaxis'*.
Dr Iain Duff (Harwell), *'Direct methods for solving sparse systems of linear equations'*, and *'The impact of high speed computers on scientific computation'*.

M.R.C.

VICTORIA UNIVERSITY

David Vere-Jones went to two Bernoulli Society meetings in India in the long vacation: an East Asia - Pacific regional meeting in Delhi and a Stochastic Processes conference in Benares.

Peter Thomson and Chris Atkin will be both taking a year's sabbatical leave from June.

One of the hardest workers for the Society, Esme Greig (who distributes the 7th Form Applied Mathematics booklets) was married on 10 March. We wish her all the best!

Terence Nonweiler's long-awaited textbook on Computational Mathematics has now appeared. (Did you know "mantissa" was an Etruscan-derived misnomer?)

The University Marae has taken over the house at 46 Kelburn Parade formerly occupied by part of the Mathematics Department; the Department is now in the Rankine Brown building and 44 and 48 Kelburn Parade.

Arrangements are well in hand for the Colloquium in May. Invited speakers will be Dr B. Adler (IBM New York), Prof. R. Aitchison (Hong Kong), Prof. W. Bonnor (Queen Elizabeth College London , and NZMS Colloquium Lecturer 1984), Prof. E. Hannan (ANU Canberra), our own Dr L.C. Johnston, Dr M. Osborne (ANU Canberra), Prof. Lee Peng-Yee (Singapore) and Dr J.R. Philip (CSIRO Canberra).

J.F.H.

MINISTRY OF AGRICULTURE AND FISHERIES, BIOMETRICS

There have been a couple of recent appointments to vacancies in the South Island: Roger Littlejohn has joined the Invermay Group and David Baird has joined the Lincoln Group. Roger has recently completed a PhD in stochastic processes from ANU and David comes to us from high school maths teaching.

Sarah Best, a new maths graduate from VUW, has joined the Wallaceville group as a Technician.

A recent theoretical preoccupation of the Ruakura group has been the correct ANOVA for unbalanced data. Dave Johnson, Harold Henderson, Neil Cox and Hans Hockey presented a series of talks on this topic at our annual meeting this February.

M.A.J.

CANTERBURY UNIVERSITY

Tin-On To has returned from study leave, spent mainly at the Universities of Chicago and Saskatchewan.

The Department has not been allowed to retain the Chair vacated by Professor Petersen, but instead has been given a vacancy at the lectureship level. It is expected that this position will be advertised in the latter half of this year.

Mrs Val Elley has been appointed as a Teaching Assistant in statistics.

Professor Lee Peng Yee, of the National University of Singapore, will be visiting us for most of this year. His main interests are Sequence Spaces and Graph Theory..

The Department is making a substantial move into the computing field with the purchase of an NCR Tower. This will ultimately enable the installation of terminals in about half the staff offices. We are also investigating the possible purchase of one or more personal computers.

Seminars

Professor Irving Adler, *"A contact pressure model of phyllotaxis"*.
Professor David Vere-Jones (Victoria University), *"Statistical analysis of Chinese earthquake data"*.
Dr Iain Duff (A.E.R.E., Harwell), *"The solution of sparse sets of linear equations by direct methods"*, *"Multifrontal techniques in the solution of sparse linear equations"*, and *"Direct methods for solving sparse systems of linear equations"*.
Jalal bin Jarjis (Canterbury), *"Perturbation methods for the equations of motion in general relativity"*.

R.S.L.

OTAGO UNIVERSITY

Professor William Davidson and Professor Desmond Sawyer have both announced their intention to retire at the end of 1984. Further information concerning them and their plans will appear in future issues of this NEWSLETTER.

In February, Dr Henry Levy returned from his 8 months study leave in Sweden and the U.K. While in England, he was based at Queen Elizabeth College in London - - and undertook some work in mathematical modelling and algebraic computing. In addition to visiting the Universities of Bath, Liverpool, Southampton , and Surrey, Henry attended a conference in Exeter on the teaching of mathematical modelling - - where he was pleased to bump into Dean Halford! (Their joint report on the conference appeared in the December, 1983 NEWSLETTER.) During the 3 months he was in Sweden, Henry worked in the Institute of Physics at Stockholm University (where he received some instruction in the algebraic computer language sheep) as well as at the KTH (where he gave a course of lectures in mechanics).

Professor Ivor Francis spent December and January visiting the Department of Statistics and Mathematical Sciences at the London School of Economics.

Dr David Hill organised a one week Summer School course on *"Introduction to BASIC Programming"* for the Otago University Extension. The course was designed for people with no previous programming experiences as well as for those who wanted to consolidate their knowledge of BASIC. All lectures, handouts, discussions, demonstrations, and experimentation revolved about the Mathematics Department's 12 Casio FX9000P microcomputers. Forty-one students enrolled - - and thirty-nine of them completed the course - - with high morale and a good feeling of accomplishment. The tutors for the course were: David Hill, John Clark, Dennis McCaughan, John Shanks and Paul van Mulbregt.

John Rayner gave a seminar on *"Testing for Goodness of Fit"*. It was primarily designed for Part III/Diploma students who may wish to do projects in this area of statistics. As well, a variety of special seminars are being given this year. They include a series on *"Permutation Groups and Graphs"* (by Dr John Curran), *"Programming Logic"* (by Dr Gerrard Liddell), *"Stochastic Compartmental Modelling"* (by Dr Fred Lam), and *"An Introduction to Computing with PASCAL"* (by Ewan Tempero and Paul van Mulbregt, both of whom are 1983 Otago B.Sc.Honours graduates).

In addition, the Otago University Extension is offering *"BASIC Tutorial Classes"* on a continuing basis (in association with the Mathematics Department) as well as a series of 6 evening lectures on *"What is Mathematics"* (by Dr Gloria Olive).

The 1984 President, Secretary, and Treasurer of the Australasian Region of the Biometric Society are Professor Ivor Francis, Assoc. Professor Bryan Manly, and Brian Niven, respectively. Further details concerning the Society appear elsewhere in this NEWSLETTER.

The Otago Mathematics Association sponsored a visit by Professor David Vere-Jones of VUW. They arranged for him to visit local schools as well as to address an OMA meeting on *"Proposed Changes in the 6th and 7th form Mathematics Syllabuses"*. His stimulating presentation was followed by a lively discussion. Some comments reflected the opinion that there was "too much statistics". In addition to his involvement with OMA, David gave a seminar on *"Analysis of Chinese Earthquake Data"*. (John Rayner hosted David's visit.)

G.O.

Notices

CANADIAN MATHEMATICAL SOCIETY

Members of the New Zealand Mathematical Society are advised that the NZMS has a reciprocity agreement with the Canadian Mathematical Society. This means that NZMS now receives free the Canadian Journal of Mathematics; the Canadian Mathematical Bulletin; the Applied Mathematics Notes; the CMS Notes; the Report of the Canadian Mathematics Olympiad; and the CMS Membership Directory. Members wishing to consult any of these may write to the Secretary, NZMS. As well, individual NZMS members, residing outside Canada, are entitled to a 50% reduction in the CMS membership fee. [The usual membership fee is on a sliding scale from $20 to $55 depending on annual income.] Members of the CMS receive the CMS notes and are entitled to a 50% discount on the Canadian Journal of Mathematics (usual rate $64), the Canadian Mathematical Bulletin (usual rate $35) and reduced rates for the Applied Mathematics Notes and Crux Mathematicorum. To apply for membership, write to the Secretary, CMS, 577 King Edward, Ottawa, Ont. Canada K1N 6N5.

NEW ZEALAND MATHEMATICS MAGAZINE

The New Zealand Mathematics Magazine welcomes the contribution of articles from members of the N.Z. Mathematical Society.

This magazine is read mainly by secondary school teachers as well as university lecturers and others with an interest in mathematics.

If you have an article to contribute or wish to receive a complimentary copy of the magazine please write to: The Editor, N.Z. Maths Magazine, P.O. Box 6855, Auckland 1.

BIOMETRIC SOCIETY

This year, for the first time, the principal officers of the Australasian Region of the Biometric Society are resident in New Zealand, indeed all three are at Otago University in the Department of Mathematics and Biometrics Unit: President - Professor Ivor S. Francis, Secretary - Associate Professor B.F.J. Manly, Treasurer - Mr B.E. Niven.

In cooperation with other statistical and mathematical societies the Biometric Society is planning an international Pacific Statistical Congress at Auckland University, 20-24 May, 1985. The Committee would welcome suggestions for topics, invited speakers, sources of funds, etc. and for other societies wishing to cooperate. Professor Peter Armitage will be one invited speaker. One special topic may be the use of microcomputers for statistical purposes in remote regions. Suggestions should be sent to the Secretary.

PROFESSOR DEMING's VISIT

Professor W. Edwards Deming, whose work in statistical quality control was featured on an American documentary film "If Japan can, why can't we?", which was aired twice on NZTV in 1983, will visit New Zealand to give a 4-day seminar for top management, engineers, and statisticians in Auckland May 8-11. He will give brief talks for statistical audiences in Wellington and Dunedin on May 2 and 4 respectively. Further information can be obtained from Professor Ivor Francis, Department of Mathematics, Otago University.

Book Reviews

LIFE SCIENCE MODELS, editors H. Marcus-Roberts and M. Thompson. Volume 4 in Modules in Applied Mathematics, Springer-Verlag, (1983) 366 pages, US price approx. $28.60.

It is stated that the purpose of the Modules in Applied Mathematics series is to "make available for college teachers and students samples of important and realistic applications of mathematics which can be covered in undergraduate programs ... to provide illustrations of how modern mathematics is actually employed to solve relevant contemporary problems". To this end volume 4 of the series provides 12 largely independent chapters under three headings: Population Models, Biomedicine, and Ecology.

A major difficulty in producing a book like this is obviously in getting the contributions from different authors to blend together. From this point of view I feel that the editors have not altogether succeeded. In particular, the level of mathematics varies in an apparently haphazard manner from chapter to chapter so that there is no particular group of students that the material is aimed at. There is a range from a chapter on molecular genetics that involves nothing more than multiplication, to a chapter on several species ecosystems that is suitable for graduates.

There are four chapters on population models. The first three contain fairly standard material, are well presented, and could form the basis for part of a third or fourth year course on modern applications of mathematics. The fourth chapter (this is the one on several species ecosystems) comes into a different category altogether. It is about as long as the other three chapters combined, and written at a deeper level. This is indicated by a list of 71 references in English, German, Russian and Italian. (We are told that in some cases translations may be available!) I do not think that this chapter is suitable for undergraduates, although the material is interesting. It could be a basis for an honours project, or as a course for M.Sc. students with a particular interest in mathematical application in biology.

In the section on biomedicine there are five chapters - three on epidemics, one on molecular genetics, and one on cigarette filtration. The three on epidemics would be suitable for third or fourth year students. The one on molecular genetics is more biology than anything else and does not seem particularly suitable for a mathematics course. The chapter on cigarette filtration is a good application of calculus.

Finally, under the heading of ecology we find two chapters on energy use in obtaining food, the first for humans and the second for other animals. These are quite technical, with long lists of references, although the mathematics is fairly straight forward. To use them properly would need a good deal of lecture time. The last chapter is then on the spatial distribution of butterfly eggs and is a good application of standard methods of probability theory.

Certainly anyone planning a course involving some examples of mathematics and statistics applied to biology should look at this book. The examples do succeed in demonstrating the value of the mathematical approach. They are a good introduction to how mathematics is currently being used to solve problems in biology.

Bryan Manly

THE GEOMETRY OF DISCRETE GROUPS, by Alan F. Beardon, Springer-Verlag, New York (1983), 337 pages, US price approx. $44.60.

This book is one of Springer-Verlag's Graduate Texts in Mathematics and deals with the geometrical ideas involved with groups of Möbius transformations. This topic brings together the methods and results of several mathematical disciplines as indicated in the first two chapters of the text, which inform the reader of the basic algebra, complex analysis, measure theory and topology used in the chapters to follow. Lest this seem to place too much prerequisites on the reader, let us hasten to add that most of the material in these two short chapters is covered in standard undergraduate courses in New Zealand. Moreover, as Dr Beardon indicates in Chapter 7, the main prerequisite really seems to be "both an acceptance and understanding of Euclidean geometry" and he adopts this stance with the conviction that, although some of the results presented may be proved more simply by, say, matrix methods, it is the geometrical explanation which provides the insight to the material.

Möbius transformations on $\hat{\mathbb{R}}^n$, the extended Euclidean n-space, are defined in Chapter 3 to be finite compositions of reflections in spheres in $\mathbb{R}^n$ or planes in $\hat{\mathbb{R}}^n$ and then their fundamental properties and those of isometries are examined. The Poincaré extension of Möbius transformations from $\hat{\mathbb{R}}^n$ to $\hat{\mathbb{R}}^{n+1}$ is also covered here. Chapter 4 then specialises to the action of these transformations on the extended complex plane $\hat{\mathbb{C}}$ and their extensions to $\hat{\mathbb{R}}^3$. It is first shown that M, the set of orientation-preserving Möbius transformations of $\hat{\mathbb{C}}$ onto itself consists precisely of the mappings g of the form

$$g(z) = \frac{az + b}{cz + d}$$

where a, b, c, d are fixed complex numbers such that $ad - bc \neq 0$. Indeed this latter expression is often used as the definition of Möbius transformation in the $\hat{\mathbb{C}}$ case. The resulting nonsingular matrix

$$A = \begin{bmatrix} a & b \\ c & d \end{bmatrix}$$

is then used to classify the transformations by relating the number of fixed points to the trace of A. The rest of this chapter further exploits the relationship between the matrix representation and the geometry.

Elementary groups are introduced in Chapter 5 as a prelude to discussion of discrete subgroups of M and discontinuous actions. The short Chapter 6 treats Riemann surfaces, their construction using groups of Möbius transformations on $\hat{\mathbb{C}}$ and introduces Fuchsian groups.

As mentioned, the author's intention is to emphasise the geometrical aspects of the theory and for this he has included a large Chapter 7 (more than 60 pages) on hyperbolic geometry. This has been presented with emphasis on the analysis, rather than from an axiomatic viewpoint, and in terms of Euclidean geometry. The chapter and the others to follow are enhanced by many diagrams illustrating the theory and concepts. This material on hyperbolic geometry should prove to be a useful reference source for those researching into the geometry of groups.

The rest of the book concentrates on Fuchsian groups, previously introduced in Chapter 6. The geometrical presentation of these groups, begun in Chapter 8, could complement well their more abstract, combinatorial treatment given recently in a Springer Lecture Notes volume, *"Surfaces and planar discontinuous groups"*, by H. Zieschang , E. Vogt and H. Coldeway. Fundamental domains, tesselations and related polygonal domains are treated in Chapter 9, ending in Poincaré's Theorem which provides a method of constructing Fuchsian groups from geometry. The last two chapters deal with finitely generated Fuchsian groups and uniformity questions. The text *"Noneuclidean tesselations and their groups"* by W. Magnus, Academic Press, 1974, will serve as a useful companion to this material.

The production of the text is, as we have come to expect from Springer-Verlag, of a high quality and the author has presented the material most carefully. The book is strongly recommended for library purchase and to anyone interested in the geometrical side of group theory.

John Clark

SPRINGER-VERLAG PUBLICATIONS

Springer-Verlag have offered to send the Society free copies of their following publications if they are to be reviewed in the NZMS Newsletter. If members are interested in reviewing any of these, please contact John Clark, Mathematics Department, University of Otago.

Intersection Theory, by W. Fulton (Ergebnisse der Mathematik und ihrer Grenzgebiete Vol. 2), 470 pages.

Geometrical Methods of Nonlinear Analysis, by M.A. Krasnosel'skii and P.P. Zabreiko (Translated from the Russian by C.Fenske)(Grundlehren der mathematischen Wissenschaften, Vol. 263), 409 pages.

The Mathematics and Physics of Disordered Media: Percolation, Random Walk, Modeling, and Simulation. Proceedings of a Workshop held at the IMA, University of Minnesota, 1983 (Lecture Notes in Mathematics Vol. 1035), 431 pages.

Discretization Methods for Stable Initial Value Problems, by E. Gekeler (Lecture Notes in Mathematics Vol. 1044), 201 pages.

Differential Geometry. Proceedings of the International Symposium held at Peniscola, Spain, 1982 (Lecture Notes in Mathematics Vol. 1045), 194 pages.

Algebraic K-Theory, Number Theory, Geometry and Analysis. Proceedings of the International Conference held at Bielefeld, Germany, 1982 (Lecture Notes in Mathematics Vol. 1046), 464 pages.

Formally p-adic Fields, by A. Prestel and P. Roquette (Lecture Notes in Mathematics Vol. 1050) 167 pages.

Problems

Sub-edited by A. Zulauf, University of Waikato

PROPOSALS of problems should be sent to the sub-editor and should be accompanied by solutions and/or relevant references, comments, etc.

SOLUTIONS should be sent to the sub-editor within three months from the publication of each problem. If you discover that a problem has already been mentioned or solved in the literature, please send full details to the sub-editor.

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Comments on Problems 8 and 8a

It has been determined that $K(5) = 92$, and the answer to Problem 8a1 is therefore 'yes' Can anyone produce a short proof of this without actually determining the value of $K(5)$? No progress has been reported on any of the other questions raised in this set of problems.

Comment on Problem 11

B.R. Stokes of Auckland T.C. (formerly of Hamilton T.C.) found two solutions! To prove uniqueness, assume that x is not the smallest of the 16 integers. (The assumption $w < x$, which reduces the problem to a mini-problem, of course ensures this.)

Problem 12 *(A sequence of near-integers)*

Someone (M. Gardner?) mentioned somewhere (I cannot find the reference) that $e^{\pi\sqrt{163}}$ is very nearly an integer. Moreover, I am told, there are other near-integers of the form $e^{\pi\sqrt{n}}$ with integer n. My problem is in two parts.

(a) Prove that if n is an integer, but not a perfect square, then $e^{\pi\sqrt{n}}$ is not an integer.

(b) Using your own appropriate definition of "near-integer", exhibit, or prove the existence of, as many near-integers in the sequence $\{e^{\pi\sqrt{n}}\}$ as you can.

Sub-editor

Problem 13 *(A cycling algorism)*

Let b and p be given integers, $b \geq 2$. For every positive integer n, let its successor $s(n)$ be defined to be the sum $(\sum d_j^p)$ of the p-th powers of the b-ary digits of $n(=\sum d_j b^j)$. The sequence $S(n) = \{n, s(n), s^2(n), \ldots\}$ has a non-recurring initial segment of finite length ≥ 0 and then goes into a recurring cycle of length $L(n) \geq 1$.

(a) For what values of b and p does the equation $n = s(n)$ have a solution other than the trivial $n = 1$ (so that non-trivial cycles of length 1 occur)?

(b) Determine, or estimate as well as you can, the maximum value $L_{b,p}$ of $L(n)$.

These are, I believe, unsolved problems, and partial solutions will be welcome.

Sub-editor

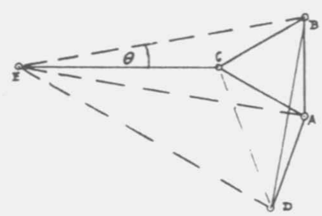
Mini-problems

The following easy problems are offered simply for the sake of interest or amusement. Readers are NOT invited to submit their solutions.

A cycling algorism

Let the sequence $S(n)$ be defined as in Problem 13 above. Show that $S(n)$ does, in fact, always go into a recurring cycle.

A remarkable pentagon



In the pentagon shown on the right

$$(1) \quad \begin{cases} |AB| = |AC| = |AD| = |BC| \\ |AE| = |BE| = |DE|, \quad |BD| = |CE| \end{cases}$$

Using only elementary properties of triangles (no co-ordinate geometry, no trigonometric equations, not even Phythagoras' theorem), find the angle $\theta = \angle BEC$, and show that AC and DE are parallel. Given an equilateral triangle ABC , do the conditions (1) determine D and E uniquely in the plane of ABC ?

Sub-editor

Letters to the Editor

UE EXAMINATION

The position of the University Entrance examination, over which there is at present so much controversy, is a matter of direct professional concern to mathematicians because of the effect it has on the teaching of mathematics at both secondary and tertiary levels. I'd be very interested to learn, through the correspondence columns of the Newsletter, what the views of my colleagues are on this question. Perhaps I can start the ball rolling by putting forward some thoughts of my own.

As a university teacher, I find the present system very awkward to handle, because students enter first-year courses with such varying backgrounds. Much of our time in our first-year calculus course, for example, is spent covering seventh-form material because we have to cater for students who have only sixth-form mathematics. This often bores students who have done and understood seventh-form mathematics, yet the pace is rather too hot for many of those who have only University Entrance mathematics. From the point of view of my own teaching, I would prefer students to have a more uniform background, and would therefore support a move to make entrance to university take place from the seventh form rather than the sixth. However, I see no great advantage in public examinations, either at sixth or seventh form level, and would be happy to have assessment done by the schools, and do away with the University Entrance examination itself. As far as the allocation of bursaries is concerned, all students could receive the same basic bursary to start with, and adjustments could, if desired, be made after the first year of tertiary study.

The sixth-form mathematics programme should, in my view, be one appropriate for all students at that level, not directed specifically at the needs of the universities. At the seventh-form level, I think there should be a basic core of material which all students taking mathematics would cover. This core need not be large, but it should be agreed upon by the universities as the basis upon which they would teach their main-stream first-year courses. The schools would then be free to add topics of their choice to fill the allotted time for mathematics. Some would no doubt spend the extra time covering some of the work to be done at university, but the universities would neither require nor encourage this, but would teach strictly on the basis of the prescribed seventh-form core. Thus the schools would have scope for experimentation, and could allow both teachers and students to follow interesting byways without being under pressure to complete a large syllabus for a major public examination.

I believe that under the right conditions, not dominated by examination pressures, the schools will be better able to send on to the universities students who enjoy and are excited by mathematics. It would then be up to the universities to carry on the good work!

Michael R. Carter
Massey University

MASSERA

Today I received a one-line note. It said "Flash - Massera is at home, free from prison. Please help new campaign."

Massera had been a political prisoner in Uruguay for many years. A campaign by mathematicians and other academics pushed hard for Massera's release. He had been Uruguay's leading mathematician before going into politics.

The campaign, spearheaded by Henri Cartan and Israel Halperin, listed the support of the N.Z. Mathematical Society in their circulars. Our effors have now paid off, although there would be ten thousand other political prisoners in Uruguay still.

We have helped to free a political prisoner, a fellow mathematician.

Bruce Calvert
NZMS Human Rights Officer

Secretarial

TENTH ANNUAL GENERAL MEETING

The Tenth Annual General Meeting of the New Zealand Mathematical Society will be held on 7 May 1984 at Victoria University, Wellington. (Time 7.00 p.m. to be confirmed.) The meeting will be held during the 19th New Zealand Colloquium, and details of venue will be announced at the Colloquium.

NOMINATIONS

The following nominations have been received for positions on the next Council. Each is accompanied by brief biographical details submitted by the nominee:

Vice-President nominations

Dr K. Broughan, University of Waikato.
Age 40. Gained an M.Sc. in Mathematics from University of Auckland in 1968 and a Ph.D. from Columbia University, New York in 1975. Currently Senior Lecturer in mathematics at Waikato and a consultant to the University of California at Berkeley Computer Algebra and Analysis research project. Member of the Working Party appointed by the Colloquium to establish the Society (and wrote the first constitution). Member of Council 1974-1979 and Secretary 1975-1976.

Assoc. Prof. I.L. Reilly, University of Auckland.
M.Sc. (1964) and B.A. (1965), Victoria University; A.M. (1968) and Ph.D. (1970) at University of Illinois. Junior Lecturer at Victoria, 1964-1966, Teaching Assistant at Illinois, 1966-1970. Took up Lectureship at University of Auckland in 1970 and now Associate-Professor.
Research and publication interests in topology and mathematics education.
Founder member of NZMS and served on Council as Treasurer 1976-1979. Convenor of the NZMS Publications Committee from 1982. President of the Auckland Mathematical Association, 1977-1979 and new Subject Convenor for Mathematics on NZ Universities Entrance Board (from 1985). Also member of the American Mathematical Society, Fellow of the IMA.

Council Nominations

Dr J.F. Harper, Victoria University.
Reader in Mathematics at VUW, having graduated M.Sc. there (1960) in mathematics; Ph.D. (Cambridge 1964); Junior Lecturer, VUW 1960; Lecturer, Bristol, U.K. 1963-1967; Senior Lecturer VUW 1968-1974, Reader 1975- .
Research interest in theoretical fluid dynamics and its applications to biophysics, geophysics and chemical engineering.
Member of Royal Society of NZ, Wellington Branch, including service as Chairman of Geophysics Section and Secretary. Founder member of NZ Geophysical Society, including service as Treasurer of its first conference. Founder member of NZMS and VUW Newsletter correspondent.

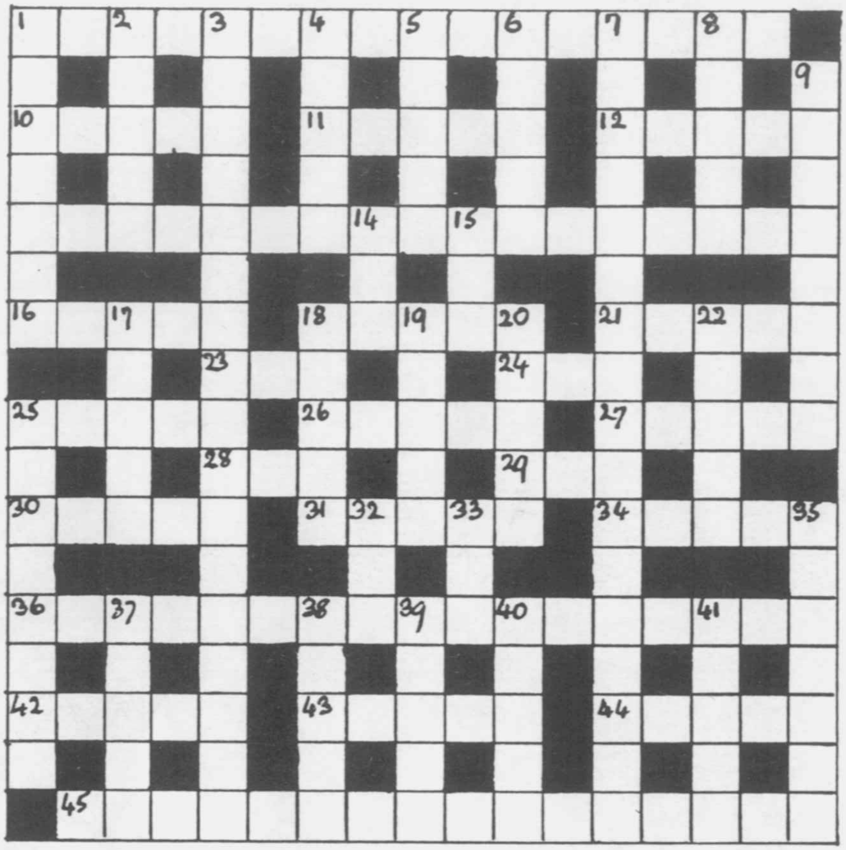
Dr M.A. Jorgensen, Ministry of Agriculture and Fisheries, Wellington.
B.Sc.(Hons), Canterbury 1966, M.A. and Ph.D. in mathematics, British Columbia 1972.
Scientist at AMD, Mount Albert, 1966-1967, and then Teaching Assistant at British Columbia 1967-1971. Assistant Professor at Waterloo Lutheran University 1971-1973. From 1973 to present Scientist in Biometrics Section of Min. of Agriculture and Fisheries, apart from a period (1977-1979) as Lecturer at the University of Botswana and Swaziland.
Research interests in mathematical models in management of renewable biological resources, analysis of categorical data with latest structure models, interfacing statistical and database computer packages.

Dr R.G. Kalnins, University of Waikato.
B.Sc.(Hons) University of Canterbury 1967; M.Sc. (1968) and Ph.D. (1972) at University of Western Ontario. Centre de Recherches Mathématiques, Montreal, 1972-1975. Appointed to Waikato in 1975 and presently a Senior Lecturer in mathematics.
Research interests centre mainly on the study of Lie groups and their application to the study of special functions and partial differential equations.

Dr C.H.C. Little, Massey University.
Born 12.2.47, Bangor, Wales. B.Sc.(Hons), Toronto, 1968; M.Sc., Toronto, 1969 and Ph.D. Waterloo, 1973. Accepted appointment as Lecturer at the Royal Melbourne Institute of Technology Limited in 1973, and remained there until 1982 with the exception of a year lecturing at Purdue University. Assumed current position as Lecturer at Massey in May 1982.
Research interests in graph theory and combinatorics.

Crossword

Nº DON'T MENTION IT by Matt Varnish

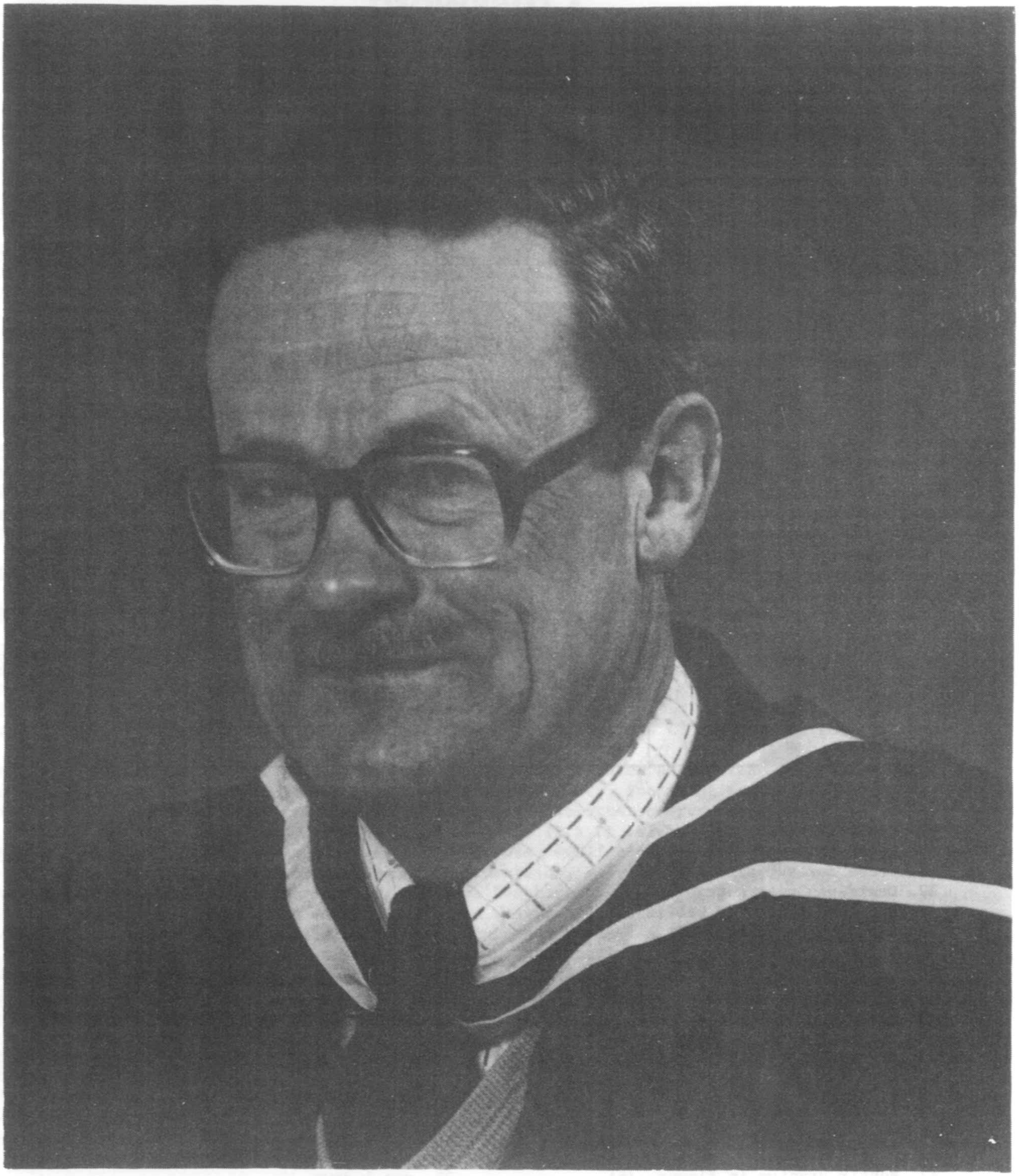


Across:

1. Hrary is a Hitchcock movie. (7,4,5)
10. Beast in a mall. (5)
11. Lease for support. (5)
12. Decreases with heat? (5)
16. The spanish end of wee folk. (5)
18. Mammoth ice blocks. (5)
21. Turf out. (5)
23 and 24. Expected anytime now. (3,3)
25. Blemish warts for grass tube. (5)
26. Engrave between? (5)
27. One to eleven on the wheelman. (5)
28. Rode with Attila. (3)
29. Cor! It's so backward it's dead. (3)
30. Capital greetings ∇. (5)
31. Prone to eructation? (5)
34. The beer's acidity is a Hebrew. (5)
36. Clue for the clueless. (3,4,2,8)
42. Bestir uranium in flower. (5)
43. Floral cup. (5)
44. Of paper feint and faces old. (5)
45. As stringless diet gives minimum anxiety. (5,11)

Down:

1 and 25. Yet death strolls to recount sorry tale. (4,3,3,5)
2. Approve π for beast. (5)
3. A twin bed chess talk uses them. (5,3,5,4)
4. Resin from a mile east. (5)
5. Debated offspring. (5)
6. Henry the master game. (5)
7. For figuring in the realistic mural. (12,5)
8. A lozenge. (5)
9. Bleak one takes a tan with a rasp. (1,7)
14. Expire with 21 spots. (3)
15. Container of a kilogram for example. (3)
17. Two metals legally wild. (5)
18. The very existence. (5)
19. The very last doings. (5)
20. Remorseful. (5)
22. Banish from the island? (5)
25. see 1 down.
32. First class game is bygone. (3)
33. Collection ready. (3)
35. Kill cur of shameface. (7)
37. Escape trap. (5)
38. Ran and cared about. (5)
39. Do they increase material? (5)
40. Spellcaster. (5)
41. Affected boredom. (5)



Centrefold

PROFESSOR WILLIAM DAVIDSON

I first met Bill Davidson when I joined the staff at Battersea College of Advanced Technology in London [1] where he was Reader in Applied Mathematics. That was way back in 1964, and I little imagined then that after such a large displacement in both space and time we would both still be together, and it is perhaps not surprising that when Bill recently announced his impending retirement, it should fall to me to write this appreciation of his career.

William Davidson was born in Ardoe, which is just south of Aberdeen in Scotland, in 1924. He was educated first at the Mary Culter East Primary School, and then the Central Secondary School in Aberdeen, which he joined at the age of twelve after winning a Carnegie Trust bursary.

In 1941, Bill left school and was temporarily employed at the Ministry of Labour before enlisting in the RAF the following year. He was assigned to the Pathfinders and spent much of the war "swinging compasses" at various airfields in Cambridgeshire. Perhaps it was his war work that first aroused Bill's lifelong interest and dedication to applied mathematics. Anyway the war's end saw Bill in the role of an instructor in the Educational and Vocational training scheme while at the same time he pursued his own studies in mathematics.

Bill was demobilised from the RAF with the rank of flight sergeant in 1946, and became a student of Mathematics at Queen Mary College, London. This was the era of G.C. McVittie and S.L. Green, and both these applied mathematicians undoubtedly had a great influence on his subsequent career. After obtaining his B.Sc. in 1950 Bill joined the Mathematics staff of Battersea College of Technology as an assistant lecturer, and continued his own studies in both Fluid Mechanics and Relativity Theory, for which he was awarded his M.Sc. in 1952.

In 1954 Bill married Irene Cook, whom he met through their common interest in a country-rambling club. That same year he became a student of W.H. McCrea and was subsequently awarded his Ph.D. for his thesis on *"Problems in Relativity and Cosmology"*. This work, which was published in a series of papers between 1957 and 1959 in the Monthly Notices of the Royal Astronomical Society, was mainly concerned with the theoretical treatment of observational relations in Cosmology, and formed the basis of much of Bill's subsequent researches. Recognition soon followed when Bill was elected a Fellow of the Royal Astronomical Society in 1958, and became a Recognized Teacher of London University in the following year. In 1963 Bill was appointed Reader in Applied Mathematics, and in 1964 he became a foundation fellow of the Institute of Mathematics and its Applications.

In 1966 Bill moved to New Zealand with his wife and two children, Malcolm and Josephine, to take up the first Chair in Applied Mathematics at Otago University. In this second period of his career Bill has continued to publish at regular intervals in the more classical areas of Relativity, and now has about fifty papers to his credit. Of particular note was the work he did with his student A.B. Evans on Newtonian Cosmology in the early seventies. Bill's more recent work includes a discussion of the theory of tests of General Relativity, and an investigation of the possibility of a variable gravitational constant, this last project being undertaken with W.H. McCrea while he was a Visiting Evans Professor at Otago.

Bill's reputation however, as an applied Mathematician must surely be linked to his contribution to the resolution of the controversy that raged among cosmologists in the fifties and sixties. The modern subject of Cosmology only became possible with the advent of General Relativity and may be dated to 1917 when papers on the subject were published by Einstein and de Sitter. Within the framework of General Relativity the cosmological problem consists in finding a model of the physical universe which is a solution of Einstein's equations. In 1948 Bondi and Gold proposed a cosmological model which does not rely on Einstein's equations. Instead they postulated the "perfect cosmological principle", which requires the universe to be uniform in time as well as space and which in view of the known expansion of the universe, requires matter to be created at a constant rate throughout space. When astronomers look at distant galaxies they are, of course, also looking into the past and this gives a means of distinguishing between the two theories. For example if the universe is both expanding and evolving, one would expect matter to have been more concentrated in past epochs and so just by counting the number of galaxies per unit volume in various regions of the sky one could hope to decide whether or not the Universe is actually evolving, or whether a steady state in fact persists. Needless to say it is not at all a simple problem in practice, and in a series of papers which appear between 1958 and 1970 Bill contributed significantly to the resolution of this problem [2] . Incidentally it is now believed that the evidence points to a fundamental singularity of the observable Universe that occurred about ten thousand million years ago, and that this was followed by hyperbolic expansion.

During the seventies Bill received further recognition for his work. Most significant was his election as a Fellow of the Royal Society of New Zealand in 1976, and the award of a D.Sc. degree by London University in 1972. I must add here that Bill was not too shy to remark to us when he broke the news, that there were very few other D.Sc.'s at Otago!

Bill has also served on many committees during the tenure of his Chair in Mathematics at Otago. Among these I must mention that in 1973 he was both a member of the N.Z. National Committee for Astronomy, President of the Otago Branch of the Royal Society, and in 1978 Chairman of the Local Organising Committee of the International Astronomical Union regional meeting at Wellington. Further, members will know that Bill is currently President of the NZMS.

In the department Bill will above all be remembered for his endeavours to keep the flag flying for classical Applied Mathematics and Modelling in our syllabuses. Bill has never been afraid to express his views or take on the opposition, and we shall all certainly miss his lively debate at our meetings! I am sure that I speak for the whole department when I wish Bill and Irene a long and happy retirement.

H.C. Levy

[1] Later to become the University of Surrey at Guildford.

[2] The interested reader could consult the survey paper by W. Davidson and J.V. Narlikar which appeared in Reports on Progress in Physics (1966).

Feature Articles

RINGING THE CHANGES

R.G.T. BENNETT

CANTERBURY UNIVERSITY

The title of this article has passed into the vernacular and I suppose most will know that it is derived from bellringing, and that change-ringing consists of ringing different permutations on the order of a set of bells. A mathematician would expect that something that relies on permuting an order with some rules about the way it is done must be shot through with applications of group theory and such is the case. Many of the applications are fairly direct although very useful in composition, but it is interesting that many facets of group theory were discovered and made use of before there was much mathematical interest in the subject, and also that one or two questions arose that were quite difficult to answer.

First I would like to give a brief personal view of why it developed in the way it did. Change ringing is a peculiarly English art, growing up in the 17th and 18th centuries. It is practised there and in countries where the Anglican church has taken it (although not now exclusively in Anglican churches). Rings of bells and ringers are found today in the rest of the British Isles, Canada, Australia, South Africa, New Zealand, Zimbabwe and U.S.A. A large bell can be rung in two ways, by striking it with a hammer and by swinging the bell itself so that it is struck by a clapper hanging freely inside it.

When bells were first rung a straight bar was used to attach the rope, but with time the quarter wheel, half-wheel and eventually a whole wheel were introduced, allowing at each stage a greater swing, a louder noise until with the full wheel the bell can be swung right upside down, round and upside down again, back and forth. As we all remember, at small amplitude the swing is isochronous but as the amplitude is increased the period rises. (One is tempted to define ringing as a "close encounter with an elliptic integral of the first kind".) The effect of this is that the period of the bell is under the control of the ringer, so that rather than each bell sounding at its own time (and in effect at random as do bells in most countries) its time of striking can be altered sufficiently to allow a set of bells of different notes and consequently different sizes to be rung in sequence repeatedly. Of course this is achieved mostly by the smaller, lighter bells being slowed up, but even surprisingly large bells can be properly controlled. (The largest rung in a set is 4 tonnes, by one man on occasion!) Bells are rung well up in practice because the work required to alter the period by a given amount is smaller near the balance.

Being able to ring different bells in order has its fascination but obviously it would soon pall, and ringers started to "ring the changes", to alter the order. (Ringers always use numbers to represent the bells in a descending scale). So after ringing down the scale 123456 for a few times they would ring 132456 then 132546 and so on, making the changes when called for by one of the ringers. Notice that the shifts are to adjacent positions, for more than this would be difficult to manage. They developed the idea of a sequence of different rows of permutations rung according to a prearranged plan, with shifts occurring each time so that each row is different from the last. From this developed the idea of a sequence of changes that never repeats a row and exhausts all permutations arriving back at the initial position. Initially all types of things were tried but systematic schemes soon became the rule. The earliest book on ringing *"Tintinnalogia of the Art of Ringing"* was printed [1] in 1668, (only three copies are extant). Duckworth, the author, says "... for within these Fifty or Sixty years last past, *changes* were not known or thought possible to be *Rang*". One method, as it is referred to, was called the plain changes, in which the different rows are produced by one bell at a time shifting through the sequence then back again, repetitions being avoided by what they called an "extream change" - it was an extra that occurred whenever the one bell reached an extreme position. This is quite systematic - we could write down specifications for a computer programme to do it easily. (See Figure 1.) Of course today we would have at our disposal considerably more advanced techniques. Consider the method published by Johnson [2] in 1956 (Figure 2). To show the difference turn it upwards with a line tracing out the path of one symbol (Figure 3). (I suppose 300 years is some kind of record!) Again this was too slow and "cross peals" were produced in which the bells are moving as much as possible.

The first ones were based on the hunt that occurs in the plain changes, but all the bells are doing it (Figure 4). When this was applied to five bells, it became known as doubles because each row is obtained from the last by a double interchange. Two things are apparent (Figure 5). The rows form a group, since they are generated by the two transpositions and another is that all the rows are of even parity.

The plain hunt formed the basis of the earliest extents of doubles. For example by using the technique of introducing an alteration everytime one bell returns to the lead (No. 1 usually) it was possible to reach 40 rows, and then it was found possible to extend this to 120 by a different alteration. Note that these alterations were "Singles" - they changed the parity.

The effect was that the starting rows ("lead heads") were a complete set of representatives of cosets of the subgroup (the plain hunt) because by starting the plain hunt from each we get the extent (S_n) and it must have been recognised that some such property existed.

```
1234
2134
2314
2341
3241
3214
3124
1324
1342
3142
3412
3421
4321
4312
4232
1432
1423
4123
4213
4231
2431
2413
2143
1243
1234
```

Fig. 1

```
111441113334433322244222
224114331143342233422411
342233422411224114331143
433322244222111441113334
```

Fig. 2

```
12345
21435
24153
42513
45231
54321
53412
35142
31524
12354
12345
```

Fig. 5

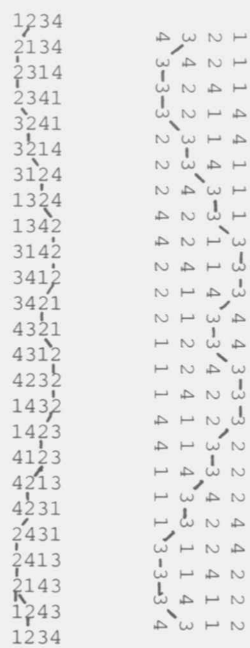


Fig. 3

```
1234    1234
2143    2143
2413    2413
4231    4231
4321    4321
3412    3412
3142    3142
1324    1324
1234    1342
        3124
        3214
        2341
        2431
        4213
        4123
        1432
        1423
        4132
        4312
        3421
        3241
        2314
        2134
        1243
        1234
```

Fig. 4

Another way of looking at the relation, which arose directly from attempting to "prove" it ("no repetitions") by other than very simple comparisons is that for any given row there are only two places it can be in one of these sections, one in the first half and another in the second. Since these are obtained by fixed rules, and the thing is symmetrical, 24153 for example can only occur if 12345 is first or last row of a section (called a lead). This immediately suggests that these rows be written down (Figure 6). Forgetting the No. 1 we have merely the 4 bell method written down backwards. This way the 24 rows with 1 first are a group (obviously) and the half lead consists of representatives of cosets.

The use of this simple method would have lead to the appreciation that "Lagrange's theorem" existed - that the "extent" consisted of the basic "lead heads" and "ends" transposed according to the half lead, all the rows with 1 in 2nds place form 1 coset, those with 1 in 3rds place form another and so on. I do not want to imply that there was any formal mathematical statement of these ideas, just that clearly, from the way they proceeded they understood the existence of this relation in a campanalogical sense.

Again consider the method called "New Doubles" (Figure 7). It is more complicated, but the rule holds that 23145 can only occur if 12345 is the first or the last row of a lead and as the rows with 1 first are the same as for the previous method a similar composition of it must be true also. This is nothing more than the usual way the coset decomposition is established. Symmetrical plain methods must have shown these facts to ringers and they were greatly exploited in the late 17th century in producing different methods. However, this brings up one last point. If we regard the whole lead (10 rows) as a complex and the lead heads as a complex, neither of which is a group, the product of these two just gives the symmetric group without repetitions. Here this arises because it depends on an underlying subgroup structure. Is this underlying structure necessary, or could we have two such complexes giving the group without it. Is there something more to be said here?

To move on, other methods brought to light other problems.

The next method of remark is called Grandsire doubles (Figure 8). Duckworth called it "The best and most ingenious method that ever was composed to be rang on five bells". The reason was that it is a systematic method which will produce sixty rows without repetition thus achieving what had come to be the aim, to ensure as much movement as possible, meaning, on five, no single changes. Of course we see at once that this is the limit. We must have a single transposition if we are to get the remaining rows of odd parity. This fact must have impressed itself on them. Duckworth doesn't seem to say definitely what he understands on this point, but he is quite clear that you can put the "single" (transposition) at any point as long as you put in another sixty rows later. The method itself is not symmetrical about the path of one bell but about the path of two. This is inevitable if we are to stick to "pure doubles". Nor are the alterations used to make greater lengths or "touches" possible at a symmetrical position. Obviously the simple rules of symmetrical methods do not apply, and in fact there is no guarantee that all the rows can be arranged into a set of "plain leads" - that is bits taking ten changes between the treble leaving the front and returning. (For example the method known as Double Grandsire does not allow the 60 even rows to be arranged into 6 leads of ten rows (Figure 9).) While by chopping it up into small enough pieces we can have them, this is regarded as unsatisfactory and by many, as beyond the pale. This harks back to the problem mentioned before. Given a "lead" (complex) $\underline{M}$ of some proposed method is there any way of determining whether a complex $\underline{L}$ exists such that $\underline{L}\underline{M} = \underline{S}_n$ just once over, other than testing all complexes of the correct size or proceeding to closure by guesswork, procedures which are feasible by hand only on small numbers?

When the Grandsire method is extended to seven bells, "triples", an entirely different position obtains and a new and intriguing problem arises. If we look at the first few rows (Figure 10) we see that they are of alternate parity with the effect that when the treble is in say 5th place going up the row is even, but when it is in the same place coming down the row is odd. This means that so long as we keep to pure triples there is only one lead head, 1234567, which can give the row 3426175. The method will run to 70 rows before returning to rounds so that we must have some additional variation known as a "bob" to shift us to other rows. This is made only when asked for by the "conductor" according to a scheme devised beforehand by the "composer". It is placed just before the treble leads but is still a triple interchange so that the regular alternation of parity is kept. The effect of this is to produce different rows and it is easy to show that any lead head of the 360 of even parity can be produced by a suitable sequence of leads of the "plain" (ordinary) and "bob" (including this special variation) varieties. If we concentrate on the latter six bells, "P" and "B" generate the alternating group, and therefore any row can be produced in this way. However, the earliest extents of 5040 all involved many singles (and sometimes extra variations). Their composers could not find an arrangement of Plain and Bob leads which would produce all the

```
12345
21435
24153  ──┐
42513    │
45231    │
54321    │
53412    │
35142    └──► 24153
31524         21435
13254  ◄───── 12345
13524
31254
32145
23415
  .
  .
  .
  .
15342
15432
  .
  .
  .
  .
14523
14253
  .
  .
  .
  .
12435  -(a)
12345
```

Fig. 6(a)

```
12345
 3254
 3524
 5342
 5432
 4523
 4253
 2435 -(a)
 2345


12345
  .
  .
14253
41523
45132
54312
53421
35241
32514
23154
B 21345
12435 -(a)
14235
41325
 etc.
```

```
     2345
     3254
     3524
     5342
     5432
     4523
     4253
B →  2435  -(a)
     4235
     2453
     2543
     5234
     5324
     3542
     3452
B →  4325
     3425
     4352
     4532
     5423
     5243
     2534
     2354
B →  3245
     2345

     120
```

Fig. 6(b)

```
12345
21354
23145  ──┐
32415    │
23451    │
32541    │
23514    │
32154    └──► 23145
31245         21354
13254  ◄───── 12345
13524
31542
35124
53214
35241
53421
35412
53142
51324
15342
15432
51423
54132
45312
54321
 etc.
```

Fig. 7

```
12345
21354
23145
32415
34251
43521
34512
43152
41325
14235
12453
21435
 etc.
```

Fig. 9

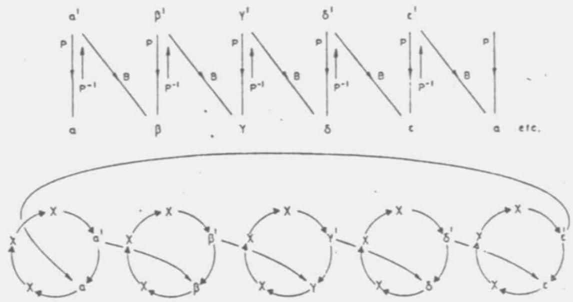


Fig. 11

	Plain course		60 even rows		
	12345		12345		13542
	21354		21354		31524
	23145		23145		35142
	32415		32415		53412
	34251		34251		54321
	43521		43521		45231
	45312		45312		42513
	54132		54132		24153
	51423		51423		21435
	15243		15243	B →	12453
–	12534		12534		14235
	21543		21543		41253
	25134		25134		42135
	52314		52314		24315
	53241		53241		23451
	35421		35421		32541
	34512		34512		35214
	43152		43152		53124
	41325		41325		51342
	14235	B →	14352		15432
–	12453		13425		14523
	21435		31452		41532
	24153		34125		45123
	42513		43215		54213
	45231		42351		52431
	54321		24531		25341
	53412		25413		23514
	35142		52143		32154
	31524		51234		31245
	13254		15324	B →	13254
–	12345		13542		12345

Plain course — 60 even rows

Fig. 8

```
+1234567
-2135476
+2314567
-3241657
+3426175
-4362715
+4637251
-6473521
+6745312
-7654132
+7561423
-5716243
+5172634
-1527364
+1253746
 2157364
 2513746
 5231476
 5324167
  etc.
  etc.
```

Fig. 10

```
    1234567
    2135476
    2314567
    3241657 ┐
    2346175 │
+   2431657 │
    4236175 ├ "Slow"          4236175 ┐
    4321657 │                 4321657 │
    3426175 ┘                 3426175 ┘
-   4362715 ┐            B →  4362157 ┐
    4637251 │                 4631275 │
    6432715 │
    2347251 ├ "Quick"
    3642715 │
    3467251 ┘
    4376521 ┐
    3475612 │
    3746521 ├ S
    7345612 │
    7436521 │
    4735612 ┘
    7453162 ┐
    7541326 │
    5743762 ├ Q
    5471326 │
     etc.   │
```

Fig. 12

rows, and yet it seemed that it should be possible, since all were within reach. The problem was evidently understood fairly completely by John Holt (?-1753), a London cobbler whose whole ringing career lasted only eight years. He produced an extent or "peal" in 1751 in which 357 leads are joined together with Plain leads and Bob leads alone, only the last 3 leads (42 rows) being produced between singles at the end. (We might be tempted to regard this as a fluke but he also composed two other extents subsequently of a different type, which indicates differently). There the matter remained for over a century. Ringers accepted that 357 leads was as much as you could get but couldn't quite understand why.

Actually the solution which I feel they were really looking for, an extent with pure triples alone, was found by Shipway in 1819 by introducing one other variation which however is still a triple interchange and which would be known to ringers as a fifth place bob. Such is the perverseness of human nature that this peal is never rung; its existence is probably known only to one in a hundred ringers, if that. Ringing had by Shipway's time taken a different line where methods were expected to use two variations or "calls", a "bob" and a "single".

Holt's peal was composed in 1751. It was not until 1886 that W.H. Thompson solved the problem again and made it clear that it is impossible to join the extent with bobs alone. His proof depends on a very simple point, what is now known, after Thompson, as the Law of the Q-sets, for which we could say Cosets. It is simply this: that if only one call is to be used, any lead head can only be got by one of two processes, by a plain lead, or a bob lead. This means that if a certain lead is obtained by a plain, then the lead that would give rise to it by a bob must be plained. Therefore we are committed to another plain lead. The result is that either we have to have plain leads preceding the set ($\alpha\beta\gamma\delta\varepsilon$), or we have to have bobs (Figure 11). The Q-sets are cosets of the group generated by $P^{-1}B$. Armed with this knowledge we can set out to make an extent. First of all we joint up all the leads into plain courses, each of 5 leads joined together in a "round block". If we choose a Q-set we will find them in 5 different loops and when we "bob" them, we will join them, together in one bigger round block. Then we find another Q-set and bob that: this joins up more leads, the exact number depends on whether we find more than one in the same round block. There are 28 possibilities but by enumerating them all, Thompson was able to show that you always added an even number of leads. As you start with 5 you can only ever end with an odd number. Curiously, the fact that you cannot join up a complete even number of sections in similar circumstances was apparent to many (it is recorded in 1788) but the application to Grandsire triples escaped them perhaps (Figure 12) because it is a good deal more complicated. Recently (1948) Rankin [3] has published a rather general theorem on this subject. His theorem can be reduced in the special case considered to the necessary condition that if the order of $P^{-1}B$ is odd, then if it is possible to join the group members into a chain (round block) using P and B alone, the indices of the cyclic groups generated by P and B must be odd. For Grandsire triples, since the group is the alternating group on 6 (order 360) and P is of order 5 and B of order 3 , the indices are both even (72 and 120) and it is impossible to join all the members into a single chain. The question of a sufficient condition has not apparently been addressed.

There is another type of method known to ringers as a "principle". A principle is a method in which all bells do the same work. Plain hunting is a principle and "plain methods" are based on it. But principles can be used as methods directly merely by having some variations, a "bob" and/or "single", which can be placed at a number of points. The only such method commonly rung is known as Stedman's principle. It is based on a very simple unit, in which the first three bells "hunt" and the back ones "dodge". (Figure 12.)

There are 14 "sixes" to a course (round block). The bob used is as shown, and it affects three bells and it may be placed between any two of the sixes. This position is not a line of symmetry because the sixes are of two sorts, called "quick" and "slow", although both exhaust the rows on the front three bells. The symmetrical positions are in the centre of the sixes but for practical purposes, calls (alterations) there would be very prone to cause difficulty and errors.

This method raises a number of intersting problems. One is a variation of the old one of whether it is possible to arrange all the rows in a set of plain leads. Obviously we can arrange them in sixes since the six is a subgroup, but for the purposes of composition this is too small a unit to be convenient. Can we arrange them in plain courses? It is believed that this is not possible but it has not been proved to be so. [Although this problem has been brought up here it is not peculiar to principles. Grandsire doubles, for example, cannot be arranged into two plain courses of even rows and two of odd rows. Symmetrical plain methods can always be so arranged because of their simple structure, but there is a class of methods very commonly rung in which the No. 1 bell has a more complicated dodging path, although still repeating itself and not being disturbed by calls, and the question of whether or not we can have all the rows arises. As there are more rows on eight bells than we normally require, it is not of great practical interest on higher numbers.]

The problem is that we would have (5040/84) or 60 such plain course blocks, but we have 360 possible starting rows. (We can obviously rotate the block to bring one of the bells back to the same starting position, and an odd parity starting row would be equivalent to going the other way). However the only "proof" offered arrived at a maximum of twenty and there are known to be sets of 40 . J. Armiger Trollope [4] wrote

> "The number of combinations of 60 blocks that could be selected from 360 is enormous and an attempt to show by experiment that not one of them can contain 5040 true rows would break the patience of a Job and exhaust the years of a Methusalah; while when we attempt to solve the problem by a more mathematical process we are baffled by the elusive nature of the factors involved."

It is possible to arrange them in 84 "bob courses", that is with every transition a bob since in that case the 60 rows exhaust the alternating group on the front 5 bells, with the other two alternating at the back. We can double this by transposing the pair at back and double each again by transposing any pair at the front. As 5040/240 = 21 and there are 21 ways of selecting a combination of 5 for the front we have just enough courses. And again the problem of the variety of calls needed occurs. Since it consists of pure triple interchanges, it gives rows of alternately odd and even parity so that on the face of it, it might be possible to get the extent with plains and bobs alone, but so far this has not been done and it is widely, virtually universally, believed to be impossible. The reason that the "law of the Q sets" in its various forms cannot be used is that we are, in fact, embarrassed by riches. While with plain methods we had to have a lead head by hook or by crook, that is by plain or bob, here we do not. If some row cannot be had as a six head because both possible antecendents have been used in their alternative parentage capability, we can still have it in the middle of a six. On top of this we do already have two extra variations beyond the plain since the two positions for bobs are technically different, one coming after quick and one after slow, so although they do not occur at the same place, a complete roundblock can be opened twice shifting two bells of the same set of 3 in the same direction. Whether this amounts to much is not clear, but it adds to the complication of any analysis.

J. Armiger Trollope went on to say from the previous quotation

> "It is also this elusiveness which makes it so difficult to prove that a true peal cannot be had by common bobs alone. That it is the fact cannot be doubted but we may be as sure of a fact as we are of anything and yet be a long way off being able to prove it mathematically."

Brave words!

Actually it is possible to join an even number (26) of bob courses into a roundblock by plains and bobs alone [5] by exploiting the two let outs that we can have an "irregular six" (that is the same set of six rows that we had in our original course, but in a different order) and that there are really two different positions for calls. Whether this can be further extended, or that by so doing we have somehow queered our pitch, is something that remains to be seen. The latter is probably the case since such attempt have been made by some very able composers over the years. Of course these questions are not of great importance for practical ringing because there are extents, mostly based on a set of composite courses which do contain all the rows discovered by Hudson and these are much more useful than anything based on the above approach could be. In any case ringing has largely gone down other avenues in recent times into methods that pose less intractable theoretical problems though not for that reason.

Today the mechanical approach is more attractive and with computers becoming even faster and more plentiful it may be that by setting up a large number of such prayer wheels working in parallel we could enumerate the possibilities at some time in the future, but at the moment this question about Stedman triples remains an interesting theoretical question yet to be solved and one the solution of which, as I have commented above, would be of no practial use to anyone; something that, I have always been led to believe, qualifies it as pure mathematics!

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THE MATHEMATICAL DIFFICULTIES OF SOME OTHERWISE ABLE UNIVERSITY STUDENTS

GORDON KNIGHT

MASSEY UNIVERSITY

That there are many people who, in areas other than mathematics, show themselves to be very able, but who find even very elementary mathematics difficult is undeniable. The reactions of one extremely able doctorate student are typical:

> "I have a daughter and she comes to me with a maths problem and I say 'Oh! go away, I don't know! In fact it upsets me to even think about it".

This article reports some of the findings of a study (Knight, 1982) designed to explore the factors behind this phenomenon.

The theoretical background for the study was essentially that of Skemp's (1979) model of intelligent behaviour. This is one of a number of recently developed information processing models which may be applied to mathematics learning. A useful feature of some of these models is that they suggest that when faced with a mathematical task a student retrieves from memory a 'framework' or 'cognitive map' which contains a variety of information about the situation. For example, when asked to explain why $3 \times 4 = 12$ a student will retrieve a 'multiplication of whole numbers' framework. If this is well developed, it might contain:

(a) a series of multiplication facts. e.g. $2 \times 4 = 8$.
(b) cross references to other frameworks. e.g. multiplication as repeated addition - 3 lots of 4 .
(c) some 'real world' examples of multiplication. e.g. three children are each given four sweets. This enables the student to know when to multiply as well as how to multiply.
(d) some properties of multiplication, e.g. multiplication makes things larger.
(e) some default procedures for solving multiplication problems if the answer is not immediately found in the framework, e.g. finding 7×8 from a knowledge of 6×8 .

The study sought to identify and compare the characteristics of the frameworks retrieved by a number of university students of differing mathematical ability, and to consider the way in which the information in the frameworks was processed.

A clinical interview method was used in which the students were led through a sequence of tasks in the arithmetic - algebra syllabus of the primary - secondary school. The students' initial responses to questions such as: 'Which is the larger, $2n$ or $n + 2$?' were probed by further questions designed to identify the structures and processes being used.

An example will illustrate the character of the interviews. One of the questions was:

$$\frac{3}{5} + \frac{1}{3} = ?$$

S_1. O.K. That's easy, that's a half, isn't it?
I_1. What makes you think that?
S_2. Well, I'd add - I think I would - I'd add the top ones and the bottom ones, four eighths, and that's a half. Is that right? (No response from the interviewer.) It's not right.
I_2. Not it's not right.
S_3. It's not. (Long pause.)
I_3. What does three fifths look like?
S_4. (Draws)
I_4. What does one third look like?
S_5. (Draws) It's going to be almost one.
I_5. It can't be a half anyway.
S_6. Oh no! There must be a rule, I don't know it.

It seems that the initial framework retrieved was entirely dominated by the incorrect, but very common, rule

$$\frac{a}{b} + \frac{c}{d} = \frac{a + c}{b + d} .$$

When this was challenged (I_2), the student had no default procedures (pause in S_3). The suggestion in I_3 prompted the retrieval of an appropriate 'fraction as part of a whole' framework. This was combined with an 'addition as the union of two disjoint sets' framework to produce the very good response 'It's going to be almost one' (S_5). However the response S_6 confirms the rule dominance of the subjects' approach to fractions.

Notice that when the information in the framework was correct and appropriate, the student had very little difficulty applying the information to the problem. This was typical of almost all of the responses in the study. Errors made were nearly always conceptual errors rather than process errors. The students made very few logical mistakes in handling the tasks, their incorrect solutions were valid deductions from false premises in the form of faulty frameworks.

If this conclusion is true in general then it indicates, firstly, the importance, to curriculum planners and teachers, of the question 'What constitutes an appropriate framework for this particular piece of mathematics?'. It seems to me that this is a valid question at all levels of mathematics teaching. What, for example, would university mathematics teachers hope to find in a 'convergence framework' or an 'analysis of variance framework?'

Secondly, the conclusion indicates the importance of monitoring the development of these frameworks in individual learners. For most, if not all, schoolchildren, success in mathematics consists of 'getting the right answer' and there is no subject area in which failure is more immediately obvious to the learner. An essay written in the English class might not be very good, but it is not 'wrong'. As a consequence an intelligent learner who is having some difficulty with mathematics may tend to use that intelligence to hide any lack of understanding by developing narrow, rule dominated, frameworks which may satisfy the immediate needs of the classroom. Because of the hierarchical nature of mathematics, these inadequate frameworks influence later learning and eventually become a jumbled mass of half remembered formulae. Periodic clinical interviews with students, particularly those who show emotional or behavioural reactions to mathematics, which are often symptoms of cognitive difficulties, might provide early identification of those at risk.

Another feature of the study was the classification of the responses to items from the major content areas: whole number, fractions, negative number, variables etc. according to the degree, and character, of the understanding shown, in an attempt to identify the content area in which the problem was most likely to arise. Fractions emerged as being by far the most likely candidate.

It seems to me that generations of curriculum planners and teachers have seriously underestimated the difficulties of learning in this area. A successful fraction framework, similar in character to that described for the multiplication of whole numbers, is very complex. Its development involves the reconstruction of previous frameworks (multiplication is no longer associated with addition and no longer makes things larger), multiple interpretations of the fractions are necessary (part of a whole, part of a set, proportion etc.), definitions and justifications are abstract rather than concrete (division is no longer 'sharing' but is the inverse of multiplication), and it is difficult to provide 'real world' examples which are within the everyday experience of the children (why would a primary school child want to divide $\frac{3}{5}$ by $\frac{1}{4}$?).

A very good case could be made for leaving all work with fractions, except for the simple understanding of the terms half, quarter, etc, which are part of everyday speech, until the secondary school. The cognitive demands of the subject matter might then be matched by the intellectual development of a higher proportion of students.

Two final comments: firstly, there was no evidence in the study to suggest that the students having difficulty were innately 'non-mathematical'. Indeed a very strong impression left was that if any one of them wished to start again, and could overcome the emotional barriers which had built up over the years, there was absolutely no reason to suppose that they would not succeed. Secondly, I came away from the experience of living with the problem over a long period no longer surprised that some intelligent people couldn't do mathematics, but surprised that anyone, intelligent or not, could.

Knight, G.H. *A clinical study of the mathematical incompetence of some university students.* Ph.D. Thesis. Massey University, 1982.

Skemp, R.R. *Intelligence, learning and action.* Chichester, Wiley, 1979.

Conferences

Compiled by Dr M.R. Carter, Massey University

1984

May 1-4 (Uxbridge, U.K.)	*Conference on the Mathematics of Finite Elements and Applications* Details from The Secretary, The Institute of Computational Mathematics, Brunel University, Uxbridge, Middlesex UB8 3PH, U.K.
May 2-4 (Montreal)	*Optimisation Days 1984* Details from C.L. Sandblom, Department of Quantitative Methods, Concordia University, 7141 Sherbrooke Street West, Montreal, Quebec H4B 1R6, Canada.
May 4-6 (West Lafayette, Indiana)	*Midwest Algebraic Geometry Conference* Details from Joseph Lipman, Department of Mathematics, Purdue University, West Lafayette, Indiana 47906, U.S.A.
May 7-9 (Wellington)	*19th New Zealand Mathematics Colloquium* Details from Dr B. Dawkins, Mathematics Department, Victoria University, Private Bag, Wellington, New Zealand.
May 13-17 (Anaheim, California)	*Computer Graphics '84* Details from National Computer Graphics Association, 8401 Arlington Boulevard, Fairfax, Virginia 22031, U.S.A.
May 14-15 (Washington, D.C.)	*Sixth Symposium on Mathematical Programming with Data Purturbations* Details from Anthony V. Fiacco, School of Engineering and Applied Science, The George Washington University, Washington, D.C. 20052, U.S.A.
May 14-18 (Melbourne)	*Australian Mathematical Society 28th Annual Meeting* Details from Dr H. Lausch, Secretary, Australian Mathematical Society 28th Annual Meeting, Department of Mathematics, Monash University, Clayton, Victoria 3168, Australia.
May 15-17 (Waterville, Maine)	*Downeast Conference on Graphs* Details from J. Gimbel, Department of Mathematics, Colby College, Waterville, Maine 04901, U.S.A.
May 16-18 (Paris)	*International Conference on Modelling Techniques and Tools for Performance Analysis* Details from Institut National de Recherche en Informatique et en Automatique, Service des Relations Exterieures, Domaine de Voluceau-Rocquencourt, B.P. 105, F-78153 Le Chesnay, France.
May 17-18 (Liège, Belgium)	*IMACS International Symposium on Modelling and Simulation of Electrical Machines and Converters* Details from H. Buysse, Unité Courant Fort et Electrotechnique, Université Catholique de Louvain, Batiment Maxwell, Place du Levant 3, B-1348 Louvain-la-Neuve, Belgium.
May 18-31 (Banff, Canada)	*Meeting on Graphs and Order* Details from Graphs and Order, Department of Mathematics and Statistics, The University of Calgary, Calgary, Alberta T2N 1N4, Canada.
May 21-23 (Brussels)	*Colloque Informatique, Logique et Mathematiques* Details from Guy Louchard, Lab. Inform., U.L.B., Campus Plaine, C.P. 212, Boul. du Triomphe, B-1050 Brussels, Belgium.
May 21-25 (Prague)	*International Spring School on Evolution Equations* Details from John Oldrich, Charles University, Department of Mathematics, 83 Skolovska, CS-18600 Prague 8, Czechoslovakia.
May 28-June 1 (Sophia-Antipolis, France)	*Simulation Numérique de la Turbulence* Details from Institut National de Recherche en Informatique et en Automatique, Service des Relations Exterieures, Domaine de Voluceau-Rocquencourt, B.P. 105, F-78153 Le Chesnay, France.
May 28-June 1 (Becici, Yugoslavia)	*16th Yugoslav Congress of Theoretical and Applied Mechanics* Details from J. Jaric, Yugoslav Society of Mechanics (16th Congress 1984), Kneza Milosa 9/i, 11000 Belgrade, Yugoslavia.

June 1-10 (Montbuisson, France)	*Problèmes à Frontières Libres - Applications et Theories* Details from Institut National de Recherche en Informatique et en Automatique, Centre de Rocquencourt, Domaine de Voluceau-Rocquencourt, B.P. 105, F-78153 Le Chesnay, France.
June 4-8 (Kalamazoo, Michigan)	*Fifth International Conference on the Theory and Applications of Graphs, with Special Emphasis on Computer Science Applications* Details from Directors, Graph Theory Conference, Department of Mathematics, Western Michigan University, Kalamazoo, Michigan 49008, U.S.A.
June 4-9 (Rome)	*International Congress: Giornate di Geometria* Details from Claudio Procesi, Dipartimento di Matematica, Istituto "Guido Castelnuovo", Università degli Studi di Roma "La Sapienza", Piazzale Aldo Moro 5, I-00185 Rome, Italy.
June 6-8 (San Diego, California)	*1984 American Control Conference* Details from AACC Secretariat, 1051 Camino Velasquez, Green Valley, Arizona 85614, U.S.A.
June 10-14 (Berlin)	*Conference on Global Differential Geometry-Global Analysis* Details from Dirk Ferus, Fachbereich 3-Mathematik, Teknische Universität Berlin, Strasse des 17 Juni 135, 1000 Berlin 12, Federal Republic of Germany.
June 11-16 (Marseilles, France)	*First International Symposium on Ordered Algebraic Structures* Details from S. Wolfenstein, Chairman, Organising Committee, Faculté des Sciences du Mans, 72017 Le Mans, Cedex, France.
June 12-14 (Boulder, Colorado)	*SIAM Conference on Numerical Optimization* Details from Meetings Arrangements, Society for Industrial and Applied Mathematics, 117 South 17th Street, Philadelphia, Pennsylvania 19103, U.S.A.
June 12-14 (West Lafayette, Indiana)	*Tenth International Symposium on Machine Processing of Remotely Sensed Data* Details from Paul E. Anuta, Purdue University/LARS, 1291 Cumberland Avenue, West Lafayette, Indiana 47906-1399, U.S.A.
June 12-16 (Gothenburg, Sweden)	*Fourteenth Conference on Stochastic Processes and their Applications* Details from Course Office, Chalmers University of Technology, S-41296 Göteborg, Sweden.
June 13-15 (Nice, France)	*1984 Conférence sur les Modèles Economiques Dynamiques et le Contrôle* Details from Institut National de Recherche en Informatique et en Automatique, Centre de Rocquencourt, Domaine de Voluceau-Rocquencourt, B.P. 105, F-78153 Le Chesnay, France.
June 18-20 (Edmonton, Canada)	*International Conference on Qualitative Theory of Differential Equations* Details from H.I. Freedman, Department of Mathematics, University of Alberta, Edmonton, Alberta, Canada.
June 18-20 (Copenhagen)	*26th International Meeting of the Institute of Management Sciences* Details from Julie Eldridge, TIMS, 146 Westminster Street Providence, Rhode Island 02903, U.S.A.
June 18-22 (Arlington, Texas)	*Sixth International Conference on Trends in the Theory and Practice of Nonlinear Analysis* Details from V. Lakshmikantham, Department of Mathematics, University of Texas at Arlington, Box 19408, Arlington, Texas 76019, U.S.A.
June 19-21 (Nice, France)	*Sixième Conference Internationale Analyse et Optimisation des Systèmes* Details from Institut National de Recherche en Informatique et en Automatique, Centre de Rocquencourt, Domaine de Voluceau-Rocquencourt, B.P. 105, F-78153 Le Chesnay, France.
June 19-21 (Bethlehem, Pennsylvania)	*Fifth IMACS International Symposium on Computer Methods for Partial Differential Equations* Details from William E. Schiesser, Department of Chemical Engineering, Whitaker Laboratory #5, Lehigh University, Bethlehem, Pennsylvania 18015, U.S.A.
June 19-23 (Northfield, Minnesota)	*Seventh Summer Symposium in Real Analysis* Details from Theodore A. Vessey, Department of Mathematics, St. Olaf College, Northfield, Minnesota 55057, U.S.A.

June 20-22 (Dublin)	*Third International Conference on Boundary and Interior Layers* Details from BAIL III Conference, 39 Trinity College, University of Dublin, Dublin 2, Ireland.
June 21-24 (Toronto, Canada)	*Conference on Bertrand Russell's Early Technical Philosophy* Details from Ian Winchester, Coordinator of the Russell Conference '84, The Ontario Institute for Studies in Education, Suite 9-196, 252 Bloor Street West, Toronto, Ontario, Canada M5S 1V6.
June 24-July 3 (Stillwater, Oklahoma)	*Analytic Number Theory and Diophantine Problems* Details from Amit Ghosh, Department of Mathematics, Oklahoma State University, Stillwater, Oklahoma 74078, U.S.A.
June 25-29 (Lyons, France)	*International Conference on the Mathematical Heritage of Elie Cartan* Details from Conférence Elie Cartan, Jean-Pierre Bourguignon, Centre de Mathématiques, Ecole Polytechnique, F-91128 Palaiseau, Cedex, France.
June 25-29 (Dundee, Scotland)	*Eighth Dundee Conference on the Theory of Ordinary and Partial Differential Equations* Details from R.J. Jarvis, Department of Mathematical Sciences, The University, Dundee DD1 4HN, Scotland.
June 25-29 (Linz, Austria)	*International Workshop on Applied Optimisation Techniques in Energy Problems* Details from Hj. Wacker, Math. Institut, Johannes-Kepler-Universität Linz, Altenbergerstrasse, A-4040 Linz, Austria.
June 25-July 6 (Bréau sans Nappe, France)	*La Mecanique Non Linéaire* Details from Institut National de Recherche en Informatique et en Automatique, Centre de Rocquencourt, Domaine de Voluceau-Rocquencourt, B.P. 105, F-78153 Le Chesnay, France.
June 26-July 7 (Windsor, Ontario)	*Canadian Mathematical Society Summer Seminar on Lie Algebras and Related Topics* Details from Lie Algebra Conference, Department of Mathematics, University of Windsor, Windsor, Ontario, Canada N9B 2P4.
July 2-6 (New London, New Hampshire)	*Gordon Research Conference on Theoretical Biology and Biomathematics* Details from Nancy Kopell, Department of Mathematics, Northeastern University, Boston, Massachusetts 02115, U.S.A.
July 2-11 (Vancouver)	*Canadian Mathematical Society Summer Seminar on Algebraic Geometry* Details from J.B. Carrell, Department of Mathematics, #121-1984, Mathematics Road, Vancouver, Canada V6T 1Y4.
July 9-13 (Ceske Budejovice, Czechoslovakia)	*Conference on Modern Algebraic Methods - Rings and Modules* Details from L. Bican, Charles University, MFF, Sokolovska 83, 18600 Praha 8, Czechoslovakia.
July 11-14 (Charleston, S. Carolina)	*Conference on Universal Algebra and Lattice Theory* Details from S.D. Comer, Department of Mathematics and Computer Science, The Citadel, Charleston, South Carolina 29409, U.S.A.
July 11-14 (Canterbury, England)	*International Conference on Statistics in Health* Details from Mrs Tessa J. Konrath, The Institute of Statisticians, 36 Churchgate Street, Bury St Edmonds, Suffolk IP33 1RD, England.
July 15-18 (Alta, Utah)	*Conference on Combinatorial Group Theory and Very Low Dimension Topology* Details from S.N. Gersten, Department of Mathematics, University of Utah, Salt Lake City, Utah 84112, U.S.A.
July 16-26 (Lancaster, England)	*NATO/LMS Advanced Study Institute on Operators and Function Theory* Details from S.C. Power, Department of Mathematics, University of Lancaster, Bailrigg, Lancaster LA1 4YL, England.
July 16-27 (Medford, Massachusetts)	*Fifth International Conference on Probability in Banach Spaces* Details from Marjorie G. Hahn, Department of Mathematics, Tufts University, Medford, Massachusetts 02155, U.S.A.
July 23-27 (Campinas, Brazil)	*Conference on Complex Analysis and Approximation Theory* Details from Jorge Mujica, Instituto de Matematica, Universidada Estadual de Campinas, Caixo Postal 6155, 13100 Campinas SP, Brazil.
July 23-August 8 (Bad Windsheim, W. Germany)	*NATO-ASI Conference on Computational Mathematical Programming* Details from K. Schittkowski, Institut für Informatik, Azenbergstrasse 12, D-7000 Stuttgart 1, Federal Republic of Germany.

July 23-August 10 (Montreal)	*SMS-NATO ASI Conference on Universal Algebra and Relations* Details from SMS-NATO ASI, Département de mathématiques et de statistique, Université de Montréal, C.P. 6128, Montréal H3C 3J7, Canada.
July 24-27 (Leuven, Belgium)	*International Congress on Computational and Applied Mathematics* Details from F. Broeckx, University of Antwerp (RUCA), Faculteit Toegepaste Economische Wetenschappen, Middelheimlaan 1, B-2020 Antwerpen, Belgium.
July 25-August 4 (St. Andrews, Scotland)	*Edinburgh Mathematical Colloquium* Details from Dorothy M.E. Foster, Colloquium Secretary, Department of Pure Mathematics, University of St. Andrews, The Mathematical Institute, The North Haugh, St. Andrews, Scotland KY16 9SS.
July 30-August 3 (São Paulo)	*Fourth Brazilian Conference on Algebraic Topology* Details from Daciberg Lima Goncalves, Instituto de Matemática e Estatistica, Universidade de São Paulo, Cx. Postal 20570, São Paulo/SP, Cep. 01498, Brasil.
July 30-August 10 (Storrs, Connecticutt)	*Conference on Arithmetic Geometry* Details from Gary Cornell, Department of Mathematics, University of Connecticutt, Storrs, Connecticut 06268, U.S.A.
August 1-3 (Como Lake, Italy)	*Second Workshop on Hadronic Mechanics* Details from R.M. Santilli, Chairman, Organisation Committee, The Institute for Basic Research, Harvard Grounds, 96 Prescott Street, Cambridge, Massachusetts 02138, U.S.A.
August 6-10 (St John's, Newfoundland)	*International Conference on Approximation Theory and Applications* Details from S.P. Singh, Department of Mathematics and Statistics, Memorial University, St John's, Newfoundland, Canada A1C 5S7.
August 6-26 (Crete)	*International Conference on Infinite Group Theory and Related Areas* Details from S. Andreadakis, Department of Mathematics, University of Athens, Panepistemiopolis, Athens 621, Greece.
August 13-17 (Perth)	*Twelfth Australian Conference on Combinatorial Mathematics and Computing* Details from Prof. C.E. Praeger, Director XII ACCMC, Department of Mathematics, University of Western Australia, Nedlands, Australia 6009.
August 19-25 (Lyngby, Denmark)	*16th International Congress of Theoretical and Applied Mechanics* Details from ICTAM, Technical University of Denmark, Building 404, DK-2800 Lyngby, Denmark.
August 19-Sept. 5 (Saint-Flour, France)	*XIVeme Ecole D'Eté de Calcul des Probabilités* Details from P.L. Hennequin, Département de Mathématiques Appliquées, Université de Clermont, B.P. 45, F-63170 Aubière, France.
August 20-25 (Ottawa)	*Fourth International Conference on Representations of Algebras* Details from V. Dlab, Department of Mathematics and Statistics, Carleton University, Ottawa, Canada K1S 5B6.
August 21-22 (Auckland)	*20th Annual Conference of the Operational Research Society of New Zealand* Details from Chris Patterson, T.A.M. Department, Engineering School, Auckland University, Private Bag, Auckland, New Zealand.
August 24-30 (Adelaide)	*Fifth International Congress on Mathematical Education* Details from ICME 5, GPO Box 1729, Adelaide 5001, Australia.
August 27-31 (Prague)	*COMPSTAT 1984: Sixth Symposium on Computational Statistics* Details from M. Novak, General Computer Centre, Czechoslovak Academy of Sciences, 182 07-Prague, P.O. Box 5, Czechoslovakia.
September 3-7 (Marburg, West Germany)	*Sixteenth European Meeting of Statisticians* Details from V. Mammitzsch, Fachbereich Mathematik der Universität, Lahnberge, D-3550 Marburg/Lahn, Federal Republic of Germany.
September 9-13 (Milan)	*Fifth Meeting of the International Society for Clinical Biostatistics* Details from ISCB-5 Secretariat, Istituto di Biometria e Statistica Medica, 20133 Milano, Via G. Venezian 1, Italy.
September 10-14 (Buenos Aires)	*Second International Congress of Biomathematics* Details from Asociacion Latinoamericana de Biomatemática, oficina 2003, Pabellón 1, Ciudad Universitaria, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Buenos Aires 1428, Argentina.

September 12-17 (Varna, Bulgaria)	*Tenth International Conference on Nonlinear Oscillations* Details from ICNO-X, Institute of Mechanics and Biomechanics, Acad. G. Bonchev Str. block 8, 1113 Sofia, Bulgaria.
September 26-29 (Aachen, West Germany)	*Fifth Aachen Symposium on Mathematical Methods in Signal Processing* Details from P.L. Butzer, Lehrstul A Für Mathematik, Aachen University of Technology, 5100 Aachen, Federal Republic of Germany.
October 15-18 (Bar-le-Dur, France)	*International Symposium on Orthogonal Polynomials and their Applications* Details from C. Brezinski, UER IEEA-M3, Université de Lille 1, 59655-Villeneuve D'Ascq, Cedex, France.
October 24-26 (Singapore)	*Workshop on Time Series and its Applications* Details from Dr K.S. Lim, Organising Secretary, Time Series Workshop, Mathematics Department, National University of Singapore, Kent Ridge, Singapore 0511.
November 7-9 (Tuscon, Arizona)	*Symposium on Foundations of Computer Science* Details from Lawrence Snyder, Department of Computer Science, Math. Sc. Building, Purdue University, West Lafayette, Indiana 47907, U.S.A.

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August 3-11 (Berkeley, California)	*International Congress of Mathematicians* Details from ICM-86, P.O. Box 6887, Providence, Rhode Island 02940, U.S.A.

CROSSWORD No. 12 SOLUTIONS

Across: 1. Conducts, 5. Scot, 8. Loci, 9. Nineteen, 10. Riemann, 13. Earth, 14. Control-points, 17. Story, 18. Schemer, 22. Eclipses, 23. Noon, 24. Disc, 25. Retrieve.

Down: 1. Caloric, 2. Niche, 3. Canon, 4. Sine, 6. Chevron, 7. Tenth, 11. Array, 12. Nulls, 13. Epoch, 15. Noodles, 16. Syringe, 17. Speed, 19. Coset, 20. Moore, 21. Tsar.

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Congratulations to Professor David Gauld on submitting the winning entry in the Intelligencer 100-word theorem competition. (See The Mathematical Intelligencer Vol. 5, No. 4, 1983.) David's theorem, written in Maori (with a rough English translation provided), proves the existence of a point of no tidal variation in the Southern Hemisphere.

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However correspondence should normally be sent direct to the Secretary, Dr J.A. Shanks, Department of Mathematics, University of Otago, Dunedin.