The New Zealand Mathematical Society

NEWSLETTER

Contents

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Publisher's Notice

The Newsletter is the official organ of the New Zealand Mathematical Society. It is produced in the Mathematics Department of the University of Waikato and printed at the University of Canterbury Printery. The official address of the Society is:

New Zealand Mathematical Society (Incorporated),

c/- The Royal Society of New Zealand,

Private Bag, Wellington.

However, correspondence should normally be sent directly to the Secretary, Dr Derrick Breach, Department of Mathematics, University of Canterbury, Christchurch, New Zealand.

Editorial

What Do Members Read And Want?

Introduction

A succession of Editors and Councils has continued to produce and pay for the Newsletter, in almost complete ignorance of **your** needs and wishes.

We appeal for your help — please **fill in the lift-out questionnaire** in the middle of this issue, and **return it to the Editor by 12 October 1987**. The next few paragraphs remind you of the Newsletter's features, some mandatory, some regular and some occasional. **Note:** the number and proportion of **non-returns** provides useful information too — usually of a negative kind!

Mandatory Services

The Newsletter covers — or it should cover — the Society's formal business: notice and minutes of General Meetings, annual reports and statements, and minutes of Council Meetings and so on. In addition, it has to give notice of the activities of the R.S.N.Z., when called on to do so.

All its other features, a goodwill gesture to members, appear by decision of the Council, or on the initiative of successive Editors.

Optional Services

Table of Conferences — Much and perhaps all of this information also appears in other places, such as the Notices of the A.M.S. or the 'Canberra Circular'.

List of Visitors — Local contacts collect the information assembled in the list of definite or possible visitors. To be any use, this list must cover New Zealand better than the 'Canberra Circular'.

Notices — The Newsletter prints much of the information it receives about vacancies, awards, prizes, books, coming events and so on.

News — The Local News needs no introduction, I hope. Alongside it appear items of General News, such as the creation of the Forder Lectureship or the formation of the M.I.S.G. in Australia.

Features — Other services include: **Book Reviews**, the **Centrefold**, occasional **Feature Articles**, and items for debate or discussion such as **Letters, Forums** or **Editorials**. Finally, the **Problems and Queries** and Matt Varnish's **Crossword** should keep you on your mental toes.

Generalities

Does the look of the Newsletter matter much to you? Did you like the TeX version in April? Should the Newsletter continue its quarto-in-a-pint-pot page size, convert to 2 columns, or shrink? How often should the Newsletter appear?

Do you want new or expanded features, a more basic product, a more 'political' flavour, active reporting, or what?

Do you feel professionally isolated in N.Z.? Should the Society try to find out what you — the Members — feel on this and other broader issues, or on the services the Society does/could/should offer?

M. Schroder.

Notices

NZMS Council and Officers

Forder Lecturer for 1989

Sir Michael Atiyah, FRS, Royal Society Research Professor, of Oxford University, has agreed to be the second Forder Lecturer. He will visit New Zealand in 1989, probably during the first term.

Feature Articles

Mathematical Modelling: A Personal View

N. G. Barton

Five main points are covered in this article:

1. **a definition of mathematical modelling,**
2. **why it is necessary to use mathematical models,**
3. **the costs and benefits of mathematical modelling,**
4. **general comments on how to do mathematical modelling, and finally**
5. **I shall highlight some points which merit further thought.**

In addition to these serious topics, I shall include a few examples to illustrate my points and provide some light relief for the reader. Why not glance at Example 1 at this stage? (It's with the others, just before the references.)

I should make a few disclaimers. Many of the ideas in this article have been stolen from other sources; I am particularly indebted to Bob Anderssen for his written ideas on the subject [1] and for expounding his general philosophy to me on many occasions. There are many books on mathematical modelling (for example, see [3, 9, 12]), and I would also point out that my host institution (the CSIRO Division of Mathematics and Statistics) has published a number of articles on mathematical modelling in the DMS Newsletter (Vols 96–99). Please note also that I regard statistical modelling as a subset of mathematical modelling.

What is mathematical modelling?

Mathematics is usually defined in dictionaries as being the science of number, quantity and shape (and variability, since we have already agreed that statistics should be considered as a subset of mathematics). Other definitions that I like include Newton's "queen of the sciences" and David's "language of high technology" [4]. We also need the concept of a **model**, which is defined in dictionaries as being a miniature or abstract representation (as well as a pattern, a person or thing worthy of imitation, and a person employed to display clothing or pose). These two components allow us to make the definition

> **Mathematical Modelling:** the abstract representation of an object or system using mathematical concepts such as number, quantity, shape, variability, etc.

This article is based on a lecture given at the 1987 ANZAAS Conference held at Palmerston North. It is a pleasure to acknowledge that Dr Dean Halford (Massey University) was responsible for the organization of the relevant section on "Mathematical Sciences in the Community". [Editor: Here, I must make an apology to all those at Massey for referring to 'Dr Noel Barton's Wairakei address ...' in the last issue.]

Why construct mathematical models?

There are many reasons for constructing mathematical models. These include:

- To gain a **quantitative** understanding of an object or system. In many cases, this would be motivated by the goals of basic science, particularly "Why is it so?"

- To answer specific questions about an object or system.

- To work with a more suitable model of reality. This may mean models scaled down or scaled up, or simplified models of complex realities. Note that, if physical models are to be used, then certain scaling laws will have to be obeyed; these will undoubtedly be based on mathematical arguments.

- To assist intuition and to play an educational role. Note that this is particularly true for physical models — it is well known that intuition is aided by an accurate scale model.

- To obtain new information or insights about an object or system. This is particularly true in science and engineering in which the study of an individual entity is framed using very well established physical laws. In these cases, it is possible to make inferences outside the model. In other modelling exercises, it may be very unwise to attempt to make inferences outside the model. Examples which spring to mind are economic and biological models, in which the results obtained depend intimately on the construction of the model.

- To have proven models for decision making. (This gets us back to an earlier reason — we have to make sure that we ask the correct question about the choices confronting us).

- To "get the ball rolling". This reason is very important because the decision to build a model means that the following stages should be observed.

    a. A modelling team should be formed, with at least one member of the team being someone with mathematical skills.

    b. Present knowledge should be consolidated and literature searches performed.

    c. A general classification can be made of the work: that is, what sort of analysis is to be performed, what is the area of knowledge, what are the goals?

    d. A global and local framework can be set up, in which the requisite mathematics can be placed.

    e. Facts and interconnections can be identified.

- For political, social, environmental, military and (particularly) economic reasons. Note that mathematical models may be the **only** way that some things can be understood. (An excellent illustration is the "Star Wars" defence network being constructed in the U.S.A.)

- In some cases, physical experimentation may be impossible, unwieldy or uneconomic.

- To design large-scale or complicated systems.

This list is not exhaustive, and individual readers can doubtless add other reasons which they have encountered. May I suggest that Example 2 would now provide an interesting diversion.

Costs and benefits of mathematical modelling

The costs of mathematical modelling would appear to be quite obvious: salaries and overheads, facilities such as libraries and computers, and very little hardware in general. Note however, that mathematicians need to keep up to date, and travel to conferences and meetings is essential. The community of mathematicians is not large (for example, I have estimated that Australia has about 3000–4000 mathematicians, and Business Week (USA) quoted the figure of 103, 000 mathematicians in the United States in 1983), and it may be that only a few others are concerned with one's own speciality. It is important to meet these people and to try to enrich one's mathematical experiences as much as possible.

The benefits of mathematical modelling are abundant indeed. On the selfish mathematical side, there is undoubtedly the opportunity to open up major new areas of research. For example, operations research arose through mathematical modelling of bomber raids during World War II and nowadays, we have the related rich fields of optimization and control. Another recent example is the subject of moving boundary problems, which has become a major research area because of its undoubted industrial importance. On another selfish note, mathematical modelling experience should improve the employment prospects of mathematics graduates. The education process should also benefit: the recent overseas experience has been that the inclusion of mathematical modelling in undergraduate mathematics programs has led to increased student numbers, greater motivation to study, and a better end product (that is, students who have learned the benefits of modelling and team research). The major benefit of mathematical modelling to the community is, however, the **economic** benefit. In my experience, I have heard of several examples in which mathematical work has been stunningly cost-effective, and I have mentioned two such cases in Examples 3 and 4.

How to do mathematical modelling

There are infinitely many answers to the "how to" question of this heading. In general, however, most people that I know of would use a flowchart something like Figure 1 to describe the modelling process.

It is important to make several points about this flowchart. The **formulation** stage is absolutely crucial. It is a stage in which experience or even brilliance will be useful, and it may be performed by non-mathematicians in modelling teams. The public and non-mathematical scientists underestimate the importance of this stage.

The **solving** stage is commonly, but incorrectly, thought of as the major step. It is a step along the way, nothing more. Importantly however, it is the step which opens up the model to the vast range of mathematical technology **including the computer.** This technology is constantly improving, and the model can be manipulated mathematically using it.

The **interpretation** stage is often thought of as being the province of the statistician. Of course, statistics is important here since any model has to be fitted to data, but statistical ideas can play major roles in the **formulation** and **solving** stages as well. Another point to note is that the computer is having a major impact in at least two ways on the **interpretation** stage. Interactive data analysis is a rapidly expanding field, and the quality of graphics output (which hinges on the computer) is improving at an almost unbelievable rate.

It is also important to note that the flowchart shows feedback loops: the mathematical model can be reformulated after comparison with data, and there is also the possibility of going right back to scratch and re-defining the goals and the framework of the study.

A typical example of the mathematical modelling process is given in Example 5.

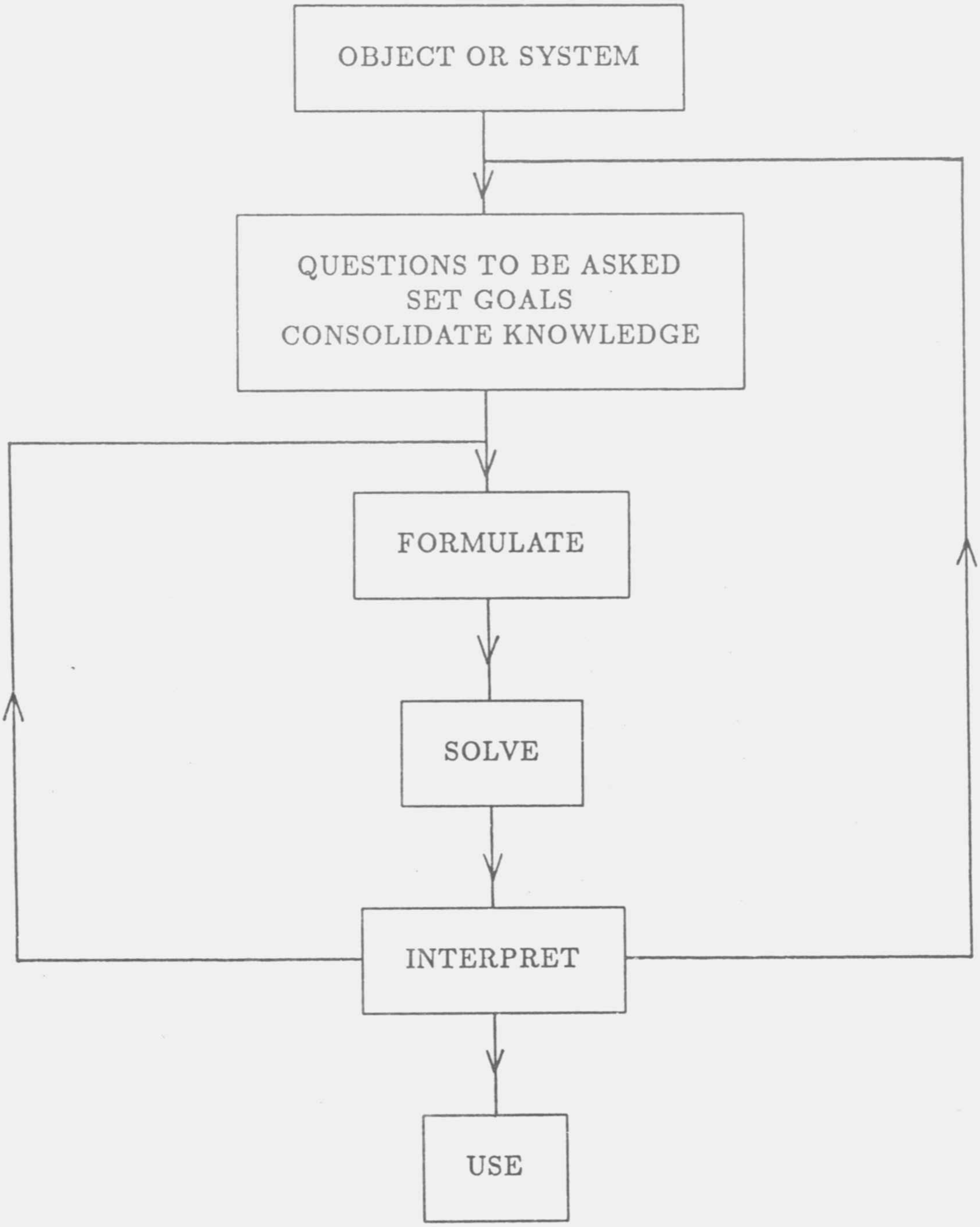

Figure 1
A flowchart to illustrate the mathematical modelling process.

Points to ponder

I have found it difficult to think of erudite closing remarks which will neatly wrap up this article, so instead, I merely invite you to keep the following handful of points in mind when considering a piece of mathematical modelling.

- **The universality of mathematics.** In mathematical physics, certain key equations (such as Laplace's equation, the wave equation, the Navier-Stokes equations, etc) are encountered time and again. Certain features are common in many models — conservation equations are an excellent example. Then certain mathematical tools are absolutely standard — matrix algebra and numerical methods are good examples. All of this makes for great efficiency: many important results can be transferred rapidly from one application to another, and it is often found that answers to particular mathematical problems already exist in the technology of mathematics.

- **The flexibility of mathematics.** Mathematical modelling is a very powerful tool in skilled hands, and mathematical models can be constructed relatively quickly.

- **The arrogance of mathematicians and the potential for misuse of mathematical modelling.** Some mathematicians have a regrettable tendency to look upon themselves as super beings who can obtain wise, morally sound, and correct answers for any problem posed to them. Nothing could be further from the truth! For a start, some problems are genuinely intractable. Further, we can all think of examples in which mathematical models have been formulated in order to arrive at conclusions which are acceptable to the sponsors of the work. Morality and intellectual honesty play no role in such cases! Mathematics is indeed a powerful tool, but it can be manipulated to support specious propositions, and the public should be aware of this possibility.

- **The importance of team research.** It may be that the age of individualism has gone, for mathematics is such an enormous field of knowledge that no one person can hope to master all of it, whilst simultaneously being capable of understanding the area of application envisaged. It is particularly noticeable that the importance of team research is stressed in those overseas universities in which modelling plays an important role in undergraduate courses.

- **When should modelling be curtailed, and how complicated should models be?** The answer lies with the original reasons for the work: modelling should cease when the specific questions have been answered, or when the new insights have been obtained. Models should be kept as simple as possible, and built up iteratively if necessary. Remember, much useful mathematics is simple in nature! Then, the costs and benefits can be considered, and modelling terminated at a point of diminishing returns. (There is an important exception to this pragmatic rule: the process of "beating a problem to death" is one which should be done by each mathematician on at least one occasion — typically during a Ph.D. thesis. There is much experience to be gained in such a way.)

- **What is "applied" or "applicable" or "useful" mathematics?** The answer is astonishingly wide in scope. In my experience, I have seen number theory used in problems involving codes and security, logic and graph theory used in the design of software, and algebraic geometry (for want of a better title) used in the computer graphics field. Useful mathematics is a veritable cornucopia of topics, and I favour the broadest possible definition. It is particularly damaging to our subject to think of (say) mathematical physics or applied statistics or optimization or numerical analysis as **the** quintessential applied mathematics.

- **How to assess the quality of mathematical modelling?** This may be an easy way to finish. Quality may be assessed by asking whether the specific questions which motivated the work been answered, and, if so, how well? — elegantly, efficiently, convincingly, etc. Remember, you can always feel the quality of the workmanship, even if you find it hard

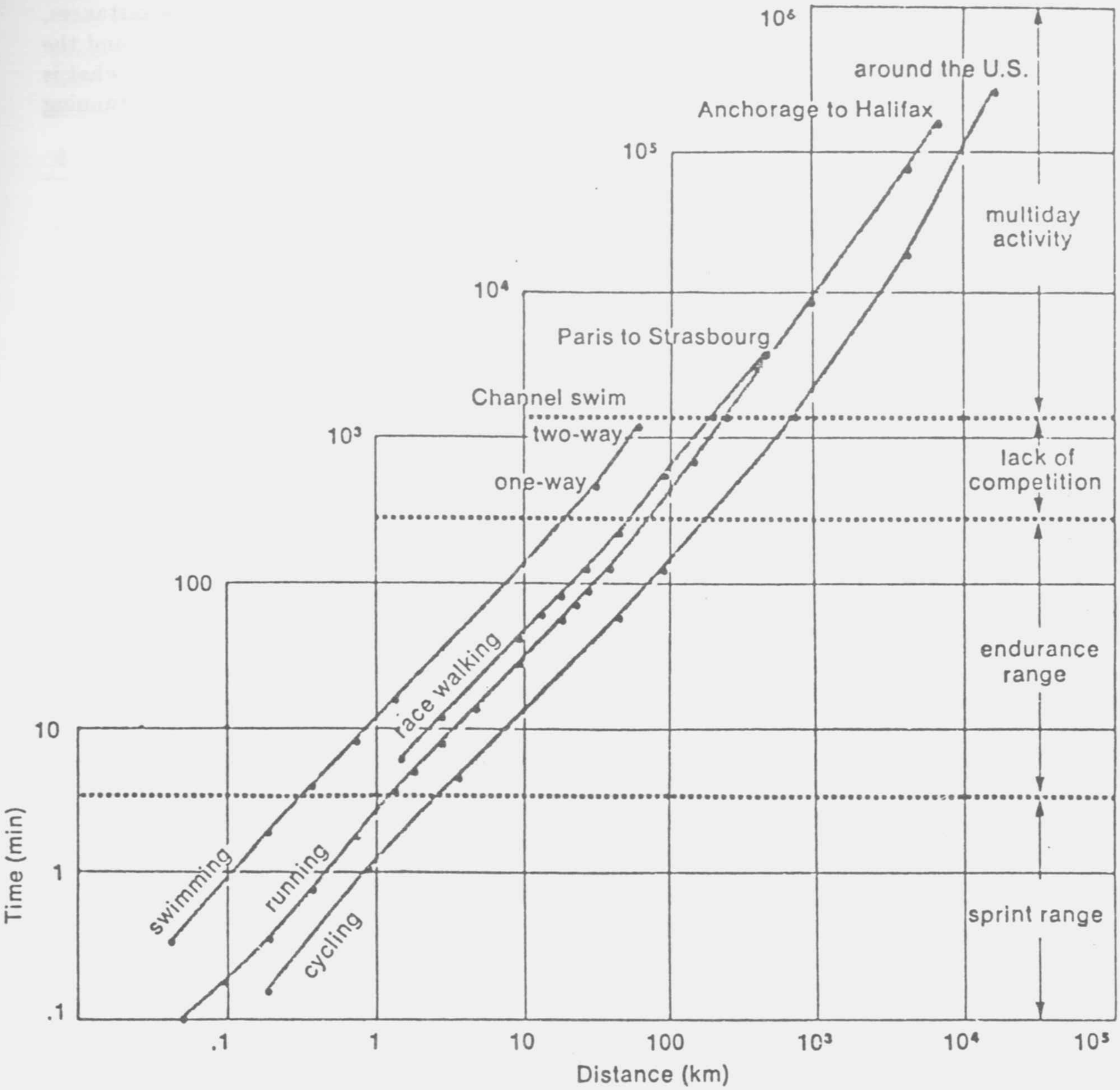

Figure 2

Human racing activity covers a large span of distance and time. This figure (due to Riegel [11]) shows world records for swimming, race walking, running and cycling.

to define quality in words!

Examples

1. A simple model of endurance

This example concerns the question of "how long will it take to perform some endurance feat?" The starting point is the remarkable diagram reproduced in Figure 2.

It may be observed that, in the endurance range, each activity appears as a straight line which represents time t as a simple power law function of distance x, say, $t = ax^b$. The constants a and b can be determined for any activity by examining best times over a range of distances, and Riegel's article [11] contains further interesting information about different sports and the endurance equations for many classes of athletes. (To inject a personal comment, I am what is derisively called a recreational runner, and I have found that this model describes my running performances very well indeed.)

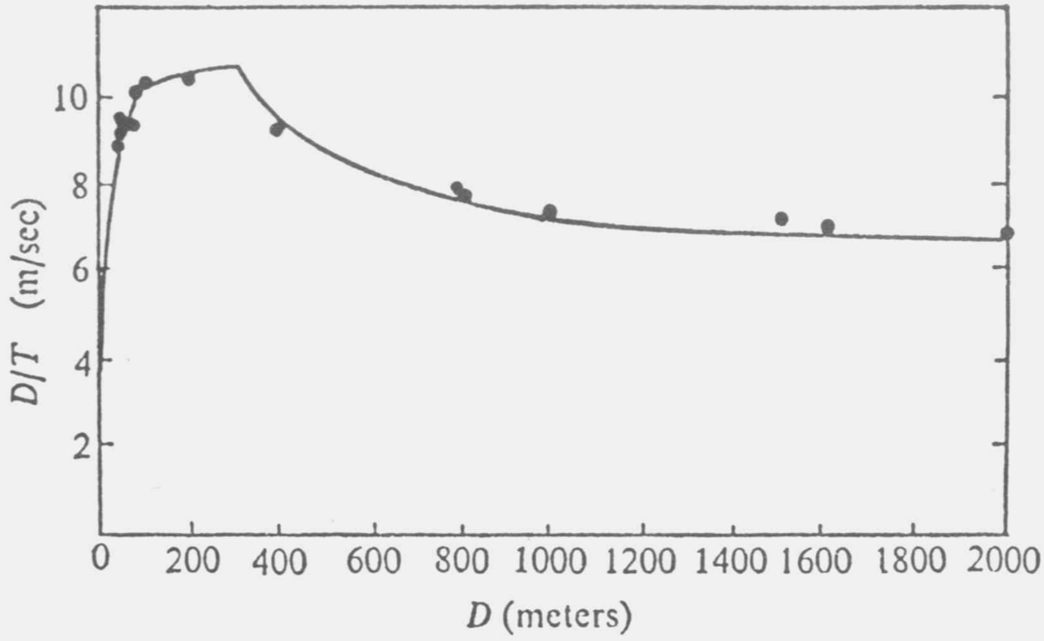

Figure 3

Keller's predictions for the average speed D/T for a race of distance D. Points show world records.

2. Optimal speed in a race

Keller [7] has constructed an elegant model to predict the optimal speed of an athlete in a race. His model involves constraints and coupled differential equations for the speed of the runner and oxygen available to the muscles. Four physiological constants (assumed known) appear in these equations.

Keller showed that the problem is equivalent to a problem in optimal control theory in which the control variable (the propulsive force exerted by the athlete) is determined using the calculus of variations and Lagrange multipliers. (An interesting article which contains many further references on investigations of sports has recently been published by Frohlich [6].)

3. Heart pacemaker communication

This topic was presented to the 1985 MISG (Mathematics-in-Industry Study Group) and concerns the communication between an implanted heart pacemaker and a laboratory programmer. Naturally, the pacemaker battery is small and needs to be conserved. Hence the uplink tends to be weak and error–prone. On the other hand, the downlink is as strong and reliable as could be wished. The problem is: what is the optimal communication code to ensure that information is transmitted reliably between the implant and the programmer and vice versa? This problem is a well-studied one in communication theory, and details are given in [2]. The economic benefit in this work is clear: mathematical work showed what could and should be done, and the manufacturer acted on the suggestions, thereby improving the performance of the implant.

4. Stresses in gas cylinders

This problem was presented to the 1986 MISG and concerns the magnitude of hoop and shearing stresses in compressed gas cylinders which are slightly out-of-round. The manufacturer had found a number of conflicting expressions for the shearing stress, and wanted to know just which one he should believe. A team of mathematicians solved this problem in three days, and the manufacturer now has clear-cut results that can be incorporated into industrial standards. I would argue that the cost-benefit ratio was astonishingly low for this exercise. Details will be presented in the proceedings of the 1986 MISG [5].

5. A simple model for the sedimentation of red blood cells

Suppose a sample of human blood is placed in a tube and the red blood cells (RBCs) are allowed to settle out of the plasma. The distance y that the interface has moved through is recorded as a function of time. This is the basis of the "erythrocyte sedimentation test" (EST) which is frequently used by haemotologists. Rapid sedimentation is a sign of disease, whilst very slow sedimentation is a feature of healthy blood. Typical results are shown in Figure 4.

It is proposed to modify the EST so that ultrasound is used to record the RBC concentration $n(x, t)$ as a function of time t and distance x below the surface of the plasma. Accordingly, the author was requested to construct a mathematical model of the sedimentation process, in order to verify and interpret any measurements which might be forthcoming. After thought, I came up with a model which I believed was original, but proved to be substantially the same as that described by Kynch [8] in a most elegant paper. This model gives a hyperbolic partial differential equation for $n(x, t)$, and it can be solved by the method of characteristics. The only experimental input which the model requires is the sedimentation speed v (or equivalently, the flux φ as a function of concentration).

It is found, however, that this model cannot predict one obvious feature of the results for the interface shown in Figure 4 — the "elbow" in the curve (at about 30 minutes for fresh blood). This feature is undoubtedly due to aggregation of the RBCs into clumps or "rouleaux"; what is required is a more sophisticated model in which sedimentation and aggregation are both included. This work is under further development and is a good example of the feedback loops shown in Figure 1. Further reading on the EST may be found in references [10, 13].

References

[1] R.S. Anderssen, *Some reasons for constructing models*, **DMS Newsletter 98** (1983), 1–3.

[2] N.G. Barton & J.D. Gray (editors), **Proceedings of the 1985 Mathematics–in–Industry Study Group** (CSIRO DMS, Canberra, 1986).

[3] W.E. Boyce (editor), **Case Studies in Mathematical Modelling** (Pitman, Boston, 1981).

[4] E.E. David, *The Federal support of mathematics*, **Scientific American 252** (1985), 25–31.

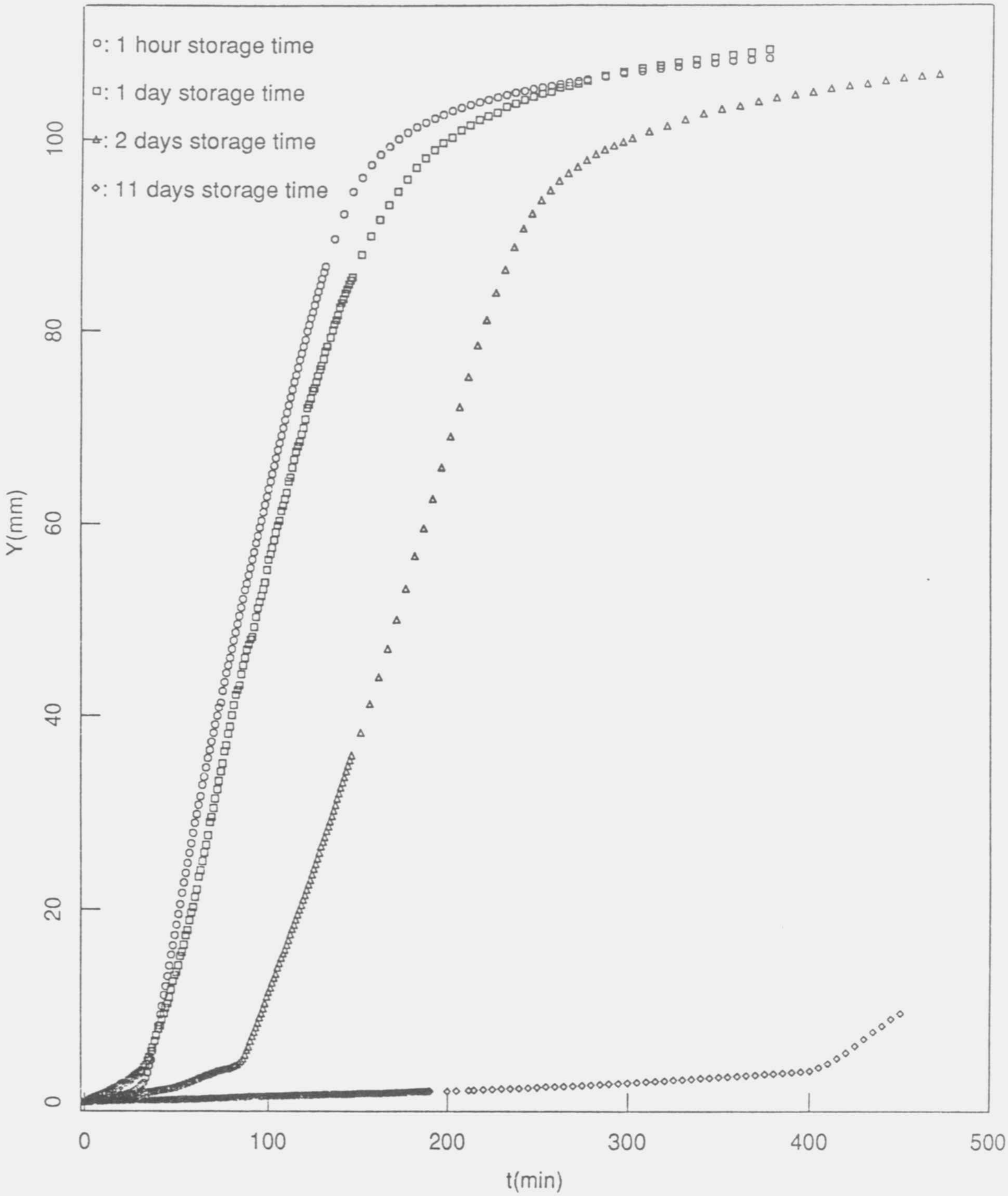

Figure 4

Sedimentation curves for one donor.
Results for four different blood storage times are recorded.
The results were obtained by Collings & Hung (CSIRO Division of Applied Physics).

[5] F.R. de Hoog (editor), **Proceedings of the 1986 Mathematics–in–Industry Study Group** (CSIRO DMS, Canberra, to be published).

[6] C. Frohlich, *Resource letter PS – 1: Physics of sports*, **Am. J. Phys 54** (1986), 590–593.

[7] J.B. Keller, *Optimal velocity in a race*, **American Math. Monthly 81** (1974), 474–480.

[8] G.J. Kynch, *A theory of sedimentation*, **Trans. Faraday Soc. 48** (1952), 166–176.

[9] C.C. Lin & L.A. Segel, **Mathematics applied to deterministic problems in the natural sciences** (Macmillan, New York, 1974).

[10] C. Puccini, D.M. Stasiw & L.C. Cerny, *The erythrocyte sedimentation curve: a semi-empirical approach*, **Biorheology 14** (1977), 43–49.

[11] P.S. Riegel, *Athletic records and human endurance*, **American Scientist 69** (1981), 285–290.

[12] A.B. Tayler, **Mathematical models in applied mechanics** (Oxford, 1986).

[13] E.A. Trowbridge, *The fluid mechanics of blood: equilibrium and sedimentation*, **Clin. Phys. Physiol. Meas. 3** (1982), 249–265.

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Reports On Science, Mathematics And Technology In New Zealand

At least five current reports deal with the present and future states of science, mathematics and technology in New Zealand. All are to be recommended as significant reading.

I. Megan Clark and David Vere-Jones of the Department of Mathematics at the Victoria University of Wellington have produced a report:

Science Education in New Zealand; Present Facts and Future Problems.

This is **#15** in the Miscellaneous Series published by the Royal Society of New Zealand, Private Bag, Wellington. It costs $6.00 plus postage.

II. The Department of Education has issued a collection of papers by various writers presented as a single book (the Blue Book) of 362 pages called

Mathematics Achievement in New Zealand Secondary Schools: A Report on the Conduct in New Zealand of the Second Mathematics Study within the International Association for the Evaluation of Educational Achievement.

III. The Minister for Science and Technology has given the NZMS permission to reproduce the whole of Sir David Beattie's introduction to the report popularly known by his name and also to reproduce the sections relevant to mathematics. The full title of the report is:

Key to Prosperity: Science and Technology. Report of the Ministerial Working Party on Science and Technology.

IV. During his tour of New Zealand, the first Forder Lecturer, Professor E.C. Zeeman, FRS, met with the President of the Royal Society of New Zealand and parliamentarians. He wrote a

Report to the Royal Society of New Zealand.

Both Professor Zeeman and Dr. Hatherton, the President of the RSNZ have given their permission for the NZMS to print the whole of this report.

V. Finally, the Central Institute of Technology, the Industries Development Commission and Massey University combined to publish

CERTECH: the Supply of Technological Skills to a Changing Economy.

Among other things, this displays the large and growing shortage of trainees fit to enter our 'high tech' future now, from technical institute or university, and the alarmingly **small** pool of scientifically literate trainees at school to follow them through this scientific apprenticeship.

Three Extracts from the Beattie Report

Chairman's Foreword

I came as a layman in scientific matters to chair this Working Party. After some five months of reading numerous submissions, hearing many witnesses and having the advantage of reading many background publications, I have become convinced that a greater investment in research and development is essential for the prosperity and social health of our country as we head towards the 21st century.

I would like to make some general observations as to why we need science and technology in New Zealand. Science and technology have the power to transform every aspect of our lives. It is vital that they become part of our national and political culture. This should start with a better understanding of science and technology by Parliamentarians, local government, senior civil servants and leaders of industry. There is an attitude existing in some circles in New Zealand that research cannot be organised to deliver economc return. I consider that future national economic success will be built on the foundations of organised scientific knowledge and capability. I am also convinced that the role of science and technology is especially significant for countries such as Australia and New Zealand which see a need to move away from their heavy reliance on primary, resource-based industries to a more diverse, and skills-based economy in order to provide insulation from downturns in markets and prices for raw comodities, and to support or improve existing standards of living. We have been production pushed rather than market led.

Although the scientist or engineer can understand that there are numerous benefits to be derived from the exploitation of new technologies, whether in electronics, telecommunications, biotechnology, production automation, artificial intelligence or new materials, to translate these potential benefits into reality requires those who are responsible for New Zealand's industries to be aware of science and technology, recognize their potential value and accept the opportunities generated.

Put in another way, the reality requires a general economic climate which promotes and rewards risk-taking and innovation together with the development of export orientated industries willing to compete overseas. I was also persuaded, from many submissions, of the need for vigorous basic research to discover or advance new technologies. This will call for closer co-operation between industry and the public research sector. I was impressed with the restrained manner in which industry in this country, primarily through the NZ Manufacturers Federation, pressed their case for means and incentives for industry to undertake high-risk research and development. One condition that we perceive as necessary to convert potential benefits into reality is a skilled management and labour force to apply the technologies to full advantage. All these matters will be canvassed in later sections of this report.

I soon came to recognise that some areas of science and technology are of potential importance not because of their relevance in terms of direct market applications, but because of other factors such as Government policy, legal constraints, public pressure, etc. Such areas relate particularly to social services like health care, the environment and consumer safety. There are other areas of science and technology which have important social implications in our multi-cultural society. For example, there is an increasing desire by women for both careers and families. New technologies will assist in meeting these desires. Individuals need to understand the concept of risk when told about the potential hazards of cancer-causing chemicals, cigarette smoking or vaccination. So the implications of science and technology in our social development are enormous. The ineluctable conclusion is that the way to help New Zealanders combat fears associated with science and technology, is through education. We shall address this vital issue later in the report.

As I began the task of preparing this report with the assistance of six distinguished citizens from very different backgrounds, I sensed that there might be a variety of irreconcilable views on the role and importance of science and technology. In the event, after thorough examination and discussion of all the evidence, unanimity was reached on all the major issues. The recommendaions in the report represent the views of all members of the Working Party.

We have endeavoured to make recommendations that will best serve the well-being of this country. For example, with regard to proposals for optimisation of the funding for government-assisted research for the best use of our dollar we have suggested a minimum requirement. On the other hand, when we recommend that New Zealand should aim to double its research and development expenditure per capita over the next seven years, we see this as essential to make possible a significant and sustainable rise in our standard of living by the end of the century.

I conclude with a message delivered in a report recently published by the Royal Society of London:

> "Science and technology play a major role in most aspects of our daily lives both at home and at work. Our industry and thus our national prosperity depend on them. Almost all public policy issues have scientific and technological implications. Public decision-makers, whether Parliamentarians, civil servants, leaders of commerce or industry or voters in a democratic society, therefore need to understand

the scientific basis of their decisions. So, too, do private individuals going about their daily lives. Everyody needs some understanding of science, its accomplishments and its limitations, whether or not they are themselves scientists or engineers. Improving that understanding is not a luxury: it is a vital investment in the future well-being of our society."

Chairman.

3. Performance in science and mathematics

a) Science

In a comparative study of achievement in science in the 1970's, part of the International Assessment of Educational Achievement (IEA) studies, New Zealand's performance was highly satisfactory at the Form 4 and Form 7 levels. This does not allow us to conclude that performance in the 1980's is equally good. We need a higher level of achievement in the future to remain competitive in the modern world.

Over the past five years there has been a small rise in the percentage of pupils taking science in Form 5, from 63% in 1980 to 65% in 1985, and steady percentages of students taking physics and chemistry in Form 6 and Form 7, in the 32%–44% range in 1985.

b) Mathematics

High standards of mathematics performance will depend on having mathematics instruction of quality from the time children enter the primary school.

An IEA assessment of mathematics in 15 countries in 1981 showed satisfactory performance by New Zealand at the Form 7 level. Weaknesses showed up at the Form 3 level. The Department of Education reported to us on the responses it had made to this information. Research of this kind is necessary for just this purpose — adjustment of instruction in response to local data collected and compared internationally.

The introduction of the New Mathematics curriculum in the 1970's was based on the best available overseas research. However, no appropriate research project was mounted in this country to monitor and evaluate the introduction of the new curriculum. If the latest results showing Form 3 weaknesses stem from the New Mathematics curriculum, a monitoring research project could have produced early warning signals leading to earlier correction of the problem. A new Junior School Mathematics programme has now been designed, and is under test in schools.

The percentage of students at Forms 5 and 6 taking mathematics has been rising and in 1985 was 93.3% in Form 5, 79.5% in Form 6, and 66.5% in Form 7.

c) Conclusion

In order to achieve the high standards of education required in an era of technological change, we see the need to monitor and evaluate new educational policies and new curricula closely so that changes can be made as soon as the need is perceived. This is one reason to increase education research expenditure from its present low level of 0.1% of the educational budget.

4. Recruitment of science and mathematics teachers

Recent moves to improve science and mathematics teaching in the primary schools deserve support. Teachers should be encouraged to develop these subjects.

There have been persistent shortages of secondary teachers of science and mathematics in most Western countries for several years. On 1 March 1986 in New Zealand there were

264 full time equivalent teacher vacancies in State secondary schools. Teacher shortages were greatest in Mathematics/Computing(19.6%), Science/Physics/Chemistry/Biology/Human Biology (17.0%), and English/Reading (14%). There was a shortage of about 100 teachers in Mathematics/Science. Core subjects in the curricula create the greatest demand for teaching and it is for these subjects that the greatest shortages occur. In New Zealand, science subject quotas for teacher education are not met, especially in physics, and the quality of applicants over recent years has resulted in students with entry scores lower than in previous years being taken into colleges of education. The downward trend started some time ago.

There are links between this problem and the growth of activity in other areas like computer science, economics and commerce. Students with high qualifications in science and mathematics can be attracted into these new areas in their university studies and then into highly paid employment in business and industry rather than into the teaching profession. This situation creates problems for the maintenance of student interest in science and technology subjects in schools, and affects the numbers of graduates who could be attracted into teaching. Many science and mathematics graduates do not wish to undertake teacher training for a further two years on the Tertiary Assistance Grant.

Numbers of applications for teacher education are known to be affected by publicity about the decline in numbers of jobs in secondary schools. As rolls drop over the next decade, an appropriate publicity campaign will be needed to maintain numbers of teachers recruited, particularly in the areas relating to science and technology.

To attract graduates into the teaching profession, the government must consider the quality and status of the teaching profession as a whole. The problem of encouraging more people into teaching subjects that prepare people for knowledge-based industry will probably not respond to simple solutions.

Report to the Royal Society of New Zealand

by Professor E.C. Zeeman, FRS.

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I should like to thank the President of the Royal Society of New Zealand both for his kind invitation to lunch and for giving me the opportunity to say a few words about the state of science in the United Kingdom and New Zealand. The recent U.K. House of Lords Select Committee Report [1] and N.Z. Beattie Report [2] show that our two countries share similar long term problems, and it is essential for us both to invest more in fundamental science now if we wish to retain our present standard of living into the next century. It is no good thinking that we can "buy in" science, otherwise the more rapidly advancing countries (like Japan, Singapore and Korea) will in the future merely sell us low technology component making while they themselves retain the high technology profit making.

The U.K. situation

Let me briefly describe the situation in the U.K. before turning to that in N.Z. In the U.K., the support of science in universities has been reduced in real terms by at least 11% since 1981 — see [1], paragraph 3.16. There are two main reasons for this: firstly, the 30% drop in birthrate between 1964 and 1974 has led to the (not necessarily correct) assumption that the number of university students will fall in the 1990's. Secondly, the policy of the present Conservative government in containing public expenditure has severely reduced the unit of resource. Since morale depends largely upon the first derivative of funding, the morale of the scientific community has suffered, complaints are many, and the brain-drain to the U.S.A. has accelerated.

On the other hand I believe the U.K.'s dual support system of the U.G.C. and the Research Councils is very good in principle. Therefore I was pleased to see the proposals in your Beattie Report recommending the establishment of a N.Z. Science and Technology Research Council (STRC) similar to our Science and Engineering Research Council (SERC). Although I think our SERC is an excellent organisation, it does suffer from one or two faults which I have observed while serving as chairman of its Mathematics Committee and member of its Science Board, so let me warn you of those pitfalls so that you may be able to avoid them when setting up your own STRC.

(i) International Agreements

The SERC makes substantial annual contributions to CERN and other European scientific organisations, at a rate fixed in U.S. dollars, but these contributions are taken out of a fixed budget. Therefore every time the pound falls relative to the dollar, the shortfall has to be taken out of the domestic budget: in other words, domestic science is sacrificed to international science. No doubt your STRC will in due course enter into collaborative international agreements or major scientific pojects with Australia and other countries, and you should make sure that the financial arrangements are tied to the appropriate exchange rates and do not interfere with your domestic science budget.

(ii) Pay Rises

Each year, the U.K. government fixes university and research council budgets before negotiating the relevant staff pay rises and then, if the subsequent pay rises are higher than the budget allowed for, does not provide any supplementary budgets to match. Consequently the universities have to cut into other essential services to pay the salary bills. For example, recently most universities have had to cut their subscriptions to learned journals by 20% or more, on top of a succession of similar cuts in previous years, which has inflicted serious long-term damage on future research potential. And last month the research councils were obliged to cancel an entire round of research grants to meet the increased salary bill. Such actions play havoc with carefully planned research programmes.

(iii) Facilities And Innovation

The SERC has difficulty in controlling the burgeoning costs on in-house laboratories and central facilities, to the detriment of research grants to individual researchers in universities. This results in a serious imbalance towards "facility-driven" research, at the expense of $\alpha-$quality innovatory "science-driven" research. It will be important to retain flexibility by requiring that most of the STRC budget be allocated to short term projects of 3 years or less.

The N.Z. Situation

Turning now to the situation in New Zealand, let me begin by welcoming the Beattie report, which is excellent both in general and in detail, especially in its recommendations on the setting up of the STRC and the mechanisms for an ongoing high-level decision-making process. I have only these three small criticisms.

(a) Cabinet Committee Chairman

In [2], recommendation 1.2 (page viii), would it not be better for the Cabinet Committee on Science and Technology to be chaired by the Prime Minister rather than the Minister for Science and Technology? Compare [1], recommendation 7.6 (page 64), which recommends that the analogous U.K. Cabinet Committee be under the chairmanship of the Prime Minister, with the designated Minister for Science and Technology as deputy. Any organisation needs two Committees, one to get the money and the other to spend it. Your new STAB (Science and Technology Advisory Board) will advise on the spending, but the Cabinet Committee will have the responsibility of providing the funding. If the Minister for Science is chairman, he will be in essence a lone voice in the subsequent battle for resources at Cabinet level, but if the Prime Minister is chairman he can accept joint responsibility with Minister for Science for presenting the case.

(b) STRC Budget

The proposed annual budget for the new Science and Technology Research Council is \$8M in 1987/88, rising to \$28M in 1991/92 — see [2], recommendation 3.1. The current SERC annual budget, however, is £350M, which (dividing by 20 for the population difference, and multiplying by 2.7 for the exchange rate) would be equivalent to a N.Z. budget of \$48M. Therefore \$28M looks far too small. Furthermore, it should not be deducted from the existing U.G.C. Block Grant, for reasons given below.

(c) Social Science Research Council

The U.K. recently changed the name of the analogous body into ESRC: the "Economics and Social Research Council". The word "science" was dropped from the title for two reasons: firstly, it had been inhibiting the funding of some activites that were desirable to support, and secondly, "social studies" is a more appropriate description than "social science" of much of relevant research.

Young Postdoctorals

Let me now turn from the Beattie Report to what I see is the single most important problem facing the universities in both our countries during the next decade. And that is to keep the brilliant young post-doctorals within the university system. The most precious commodity that the universities possess is this human resource. At present the age bulge 45–55 is preventing the recruitment of new blood, that will be desperately needed to staff the universities over the turn of the century as the age bulge begins to recede. Any method that can be devised to recruit and support the current generation of young Ph.D.'s is worth the closest attention.

Recently in the U.K. we had a remarkable New Blood scheme, whereby several hundred young scientists were appointed to tenured positions throughout the country. All science and mathematics departments were invited to submit bids for posts, each bid being accompanied by an argued case for the specific field of research in which the post would be advertised; selection of successful bids was undertaken by joint U.G.C. – Research Council Committees in each subject.

Today would be exactly the moment for N.Z. to introduce such a scheme, because there are plenty of high calibre young post-doctorals available from Europe. If the N.Z. government could increase the U.G.C. recurrent budget by \$1M per year for the next 4 years, this would be enough to recruit 50 young scientists each year. Such a policy would transform the scientific scene dramatically throughout the country, bringing new ideas to ageing departments and, at relatively little cost, laying down the seeds for a blossoming of science and international leadership in the forthcoming decades.

I would also recommend flexibility, so that if some department were able to negotiate the recruitment of a world leader, at say Nobel Prize level, then that department ought to be further supported so as to enable additional recruitment of an appropriate supporting research team.

Another idea that I am trying to encourage in the U.K. is for 10-year post-doctoral felllowships, of which the holder is paid for 4 years and allowed to intermit for up to 6 years. Such a scheme would enable young New Zealanders to spend a few years in temporary posts in the U.S.A. or Europe, with the security of being able to return to N.Z. for, say, the last two years, in order to look for a tenured post back home just at the time when the age bulge will begin to recede, and universities will need them. This scheme would also favour those with missionary zeal who would like to spend a few years teaching at universities in developing countries, without fear of losing their position in the academic race, because of the guarantee of return. It would also allow the young married academic woman to plan her family, for example after one year of fellowship to take 4 years off to have children, to return at half-time perhaps for two years, and then full-time for two years to get back into the full swing of research, thus enabling her to compete for tenured positions on an equal footing with men.

Comparisons of U.K. and N.Z. Universities

I would now like to compare the general university scheme in our two countries, taking the 1984 statistics from the 1986 edition of the Commonwealth Universities Yearbook [3]. The U.K. has 327,000 students at university, which is roughly 0.5% of the population of 60M, while N.Z. has 58,000 students, which is roughly 2% of the population of 3M. Thus the U.K. is more selective, while N.Z. is more democratic. The U.K. has a further 0.5% at polytechnics and colleges of further education, which do a slighly different job from the universities, while the N.Z. universities probably have to do both jobs.

Staff — Student Ratios	U.K.	N.Z.
Students	327,000	58,000
Staff	42,000	3,000
Staff — Student Ratio	1:8	1:19

This is a shocking statistic, and explains immediately why N.Z. staff are relatively overworked, with relatively less time to do research and compete internationally, and why N.Z. students have to be taught in large nunmbers with relatively little individual attention and practically no tutorial system.

One can massage these figures to try and improve them. For example, in N.Z. if we were to count a part-time student as 1/3 EFTS and an external student as 1/4 EFTS (= 1/3 × 80%, by the U.G.C. rule) then the N.Z. staff-student ratio would reduce to 1:14. And in the U.K. only 30,000 staff are wholly financed by universities from U.G.C. funding, and so if we were to count only them, then the U.K. figure would increase to 1:10. But no amount of massage can hide the main discrepancy.

Unit of Resource

I will now compare the unit of resource between my own university, Warwick University, which is a relatively poor new university in the U.K., and Victoria University, here in Wellington, which is a typical N.Z. university. By **unit of resource**, I mean the total recurrent budget for 1984 divided by the EFTS, calculated as the number of full-time students plus half the number of part-time students.

	Warwick	**Victoria**
Full-time students	5,029	4,897
Part-time students	518	2,703
Total EFTS	5,288	6,249
Budget	£28,660,000	$27,543,000
Unit of resource	£5,400 = $14,700	$4,400

Thus, comparing the unit of resource we see that Warwick is **more than three times** as rich as Victoria. This is the basic underlyng reason between N.Z.'s poor staff-student ratios, higher teaching loads, less time and money for research, less funding for libraries, journals, conferences, travel etc.

It is perhaps worthwhile comparing the sources of income of the two universities:

	Warwick	**Victoria**
U.G.C.	61%	90%
Fees	14%	4%
Research grants	16%	—
Other	9%	6%

The lessons are:

(i) Warwick's flexibility comes from its non-U.G.C. sources of funding.

(ii) Warwick's research grants are of crucial importance in supporting the best individual researchers in mathematics and science. Hence the importance of the Beattie recommendation of setting up the Science and Technology Research Council to fund such grants.

(iii) Warwick's U.G.C. component is still double Victoria's U.G.C. component, even though it comprises only 61% of the income, and therefore it is very important **not** to deduct your new STRC budget from your existing U.G.C. Block grant (as mentioned above in [2], recommendation 3.1).

(iv) The general conclusion from these statistics is that the problems of our two countries are not really the same. Although the U.K. scientists are grumbling because of the drop in funding, the point to which they have dropped is still well above the level of N.Z. funding. It is essential for N.Z. to substantially increase funding to its universities in fairness to the present and future generations of its youth.

Mathematics

I would like to say a few words about my own subject. Firstly may I seize the opportunity to say how honoured I am to be chosen as the first Forder Lecturer. Next may I express my appreciation of the great welcome that my wife and I have received at the Mathematics Departments of all the Universities of New Zealand. I have had enthusiastic responses to my lectures, and many interesting and lively mathematical discussions. At the same time I can see how research opportunities for mathematicians could be dramatically increased by the type of research grant funding that is at present available to U.K. mathematicians through our SERC. Therefore it is very important that, as soon as your STRC is established, it should appoint a Mathematics Committee with appropriate allocation of funds and with equal representation on the Council itself as other subjects such as physics, chemistry, biology and engineering.

School Teaching

I would like to conclude by drawing attention to the shortage of mathematics and science teachers in your primary and secondary schools. We have a similar shortage in the U.K., and our D.E.S. (Department of Education and Science) has recently issued a consultative document [4] acknowledging the crisis and appealing for ideas to help. The U.G.C. has just allocated £3M, and invited universities to submit bids, for any schemes that may help to alleviate the shortage by recruiting more teachers.

I was struck by the fact that your problem in N.Z. is in some ways worse than ours. For example, in [5] the statistics of Primary Teacher trainees shows that only 5% are majoring in mathematics and only 1% are majoring in science! Here is the very root of the problem: how can you expect your brightest children to be drawn towards science if they are not exposed to appropriate teacher enthusiasm before the age of 12?

The problem needs to be publicly acknowledged and urgently tackled. I would suggest three avenues of approach. Firstly, mathematics and science teachers should be given not necessarily more pay, but better conditions, smaller classes and more time for preparation of classes, in order to recruit more in the profession. Secondly, the expertise of mathematicians and scientists in the computing and manufacturing industries should be harnessed: such a person could be invited as a "consultant" to take a regular class on one afternoon a week. Many experts might welcome such an opportunity, and be prepared to devote some of their time, expertise and enthusiasm fo a relatively small financial reward, in order to inspire some of the oncoming generation.

Thirdly, schools can be provided with enrichment material. This is especially needed for the most gifted children who, today, are amongst the educationally most deprived. The more average children learn to work in order to keep up, and consequently realise their potential. But the more gifted are not stretched, become bored, and may drop out and never realise their potential. With today's technology, such children can be provided with a variety of material that they can use alone or with the help of teachers. For example, I myself give Mathematics Masterclasses at Warwick University on Saturday mornings for gifted 12– and 13–year-old mathematicians, and there are similar classes at 20 universities in the U.K. We have recently put the first of these masterclasses on video, with accompanyiong worksheets, which the DES is planning to give free to all local authorities for free copying by all schools.

The age 12/13 is crucial because that is when children can first appreciate abstraction, and when they are beginning to make choices between subjects that may profoundly influence their whole careers. That is the moment to catch the young New Zealand scientists of the future.

References

[1] *Civil research and development*, House of Lords Select Committee on Science and Technology, Volume 1 — Report, November 1986, H.M. Stationery Office, London.

[2] *Key to prosperity, Report of the Ministerial Working Party on Science and Technology* (Chairman: Sir David Beattie), November 1986, Wellington.

[3] *Commonwealth Universities Yearbook*, 1986, Clark Constable, London.

[4] *Shortage of Mathematics and Physics Teachers in England and Wales*, Report, Department of Education and Science, London, 1986.

[5] M. Clark and D. Vere-Jones, *Science education in New Zealand: present facts and future problems*, 47th ANZAAS Conference, Palmerston North, January 1987.

Forum

Mathematical Priorities in Secondary Education

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Paper presented to the
New Zealand Mathematics Colloquium,
Hamilton, May 1987.

There is currently a great deal of concern about the standard of mathematics and science education in New Zealand. In such a climate it seems appropriate that an evaluation of priorities be attempted. In this paper the author provides both information and opinion which may be used as a basis for discussion.

Introduction

We should all be aware of the growing concern about the state of mathematics in New Zealand schools generated, in part at least, by the second International Association for Evaluation of Educational Achievement study (1981), which tested and compared performance in mathematics in third and seventh form students from a group of OECD and other countries. Results from this have been quoted on several occasions, including the 'Beattie Report' [1] and the discussion paper prepared for the Royal Society by Megan Clark and David Vere-Jones [3]. It has even been the subject of a paper: Helen Wily's *Some Gender Differences From The IEA Survey In New Zealand* [3]. Quite an impact for a 'non-report'! The report [4] itself was not publicly available until the end of May 1987 — some 6 years after the study was completed!

New Zealand was slightly above average in mathematics at Standard 4 level in the group of countries tested (an auxiliary study), but our mean performance can only be described as abysmal at the 3rd Form level, especially in algebra and arithmetic (just better than the developing countries such as Swaziland). The mean was above average again in the 7th Form (the area of best New Zealand performance).

I will be reiterating some points already stated in previous papers. I make no apology for this: the issue of appropriate education and research into mathematics education is too important. I recently became concerned by the current situation after hearing:

(i) a senior mathematics professor state that he suspects that there has been a politically-motivated down-playing of problems in mathematics and science education [3],

(ii) a member of the Education Department say at the AGM of a local Mathematics Association that the only way to achieve real change in the current situation was for as many mathematics educators as possible to join every political party and make sure that the issue of mathematics and science education was put on every party manifesto, and

(iii) a comment voiced at the recent (June 1987) Association of Scientists seminar 'Key to Prosperity, Science and Technology', that many of the attitudes towards mathematics and science both in schools and from the public generally are reinforced by the image that mathematicians and scientists project.

What are our mathematical priorities in education?

(i) Curriculum

We have recently had a Curriculum Review [5] which proposed 'that there be a national curriculum common to all schools from new entrants to the end of form 5' (forms 6 and 7 to be an extension and continuation of this) and that each school develop a curriculum consistent with the national one. We also currently have two Mathematics Syllabus Reviews under way: one for Forms 1 to 4 and one for Forms 5 to 7. *Discussion Paper* #2 [6] for the latter of these has been circulating for some months. The major suggestion in this is to change existing courses "NZMC, S.C., ex-U.E., some S.F.C. courses, and U.B." into modules. That this idea of having subject-oriented rather than just level-oriented courses gained general support, was gathered from submissions following the release of *Discussion Paper* #1 [6]. The one point of optimism is that this may overcome some of the difficulties caused by the current gulf between 5th and 6th form mathematics. For too long, we have been content to assist 5th formers having lesser ability in mathematics to get a 'pass' in School Certificate, by teaching pattern recognition, without insisting on basic understanding. Is it any wonder that some of the less able 6th formers who can solve both

$$x + 1 = 3 \quad (\text{as} \quad x = 3 - 1) \tag{1}$$

("take constant over to other side and change sign") and

$$2x = 4 \quad (\text{as} \quad x = 4/2) \tag{2}$$

("take constant over to other side and turn upside down") then consider that $x = 1/2$ is as likely an answer to $2x + 1 = 3$ as $x = 1$ is, depending on which order the patterns (1) and (2) above are used.

However, it is my opinion that this is a relatively minor improvement in the current curricula and in a major sense, we have 'missed the boat'. Playing about with portions of the syllabus in isolation is how we arrived at the current situation, where 2-dimensional vectors and the graphical representation of addition of vectors is in the 5th form syllabus, and then not met again by mathematics students until University. In particular, it does not seem sensible to alter syllabi which have only recently been changed, without some research into the effectiveness of the original changes. Note that the Curriculum Review Committee has no formal representation from any of the professional mathematics organisations.

In my opinion, we should closely examine what we should teach and what it is feasible to teach in the following areas, as recommended in the Curriculum Review.

Table 1

Percentage of Fifth-formers Taking Mathematics

	1966	1979	1983
Females	30.8	75.1	88.8
Males	71.6	85.5	94.6
Total			93.3

Source: *Profile of Women*, Department of Statistics 1985 [6].

Up to Form 5

This does seem to be the only logical division, given the rapid upsurge in numbers taking School Certificate mathematics (Table 1). At this level, we need an attractive, applications-oriented course which concentrates on reinforcing basic numeracy skills (how do you expect 7th form pupils to add algebraic fractions if they cannot simplify $1/2 + 1/3$?), and which uses practical problems from a wide range of disciplines to develop mathematical concepts in algebra (say, economics — playing with chequebook balances) and geometry (say, constructions involved in arts and crafts).

At present, a large number of students have no perception that the study of mathematics will lead to a job, and are quickly lost to more applications-based areas such as engineering, computing and economics.

However, it is not just those students who will eventually sit some sort of external examination that we should be concerned about. When we look at Table 2, we see that an alarming proportion of the population aged 15 or over has no academic or trade qualification whatsoever.

As mathematics is an optional subject beyond the 4th form, if we want a general population with an adequate level of basic numeracy, we must confront the problem earlier, not just at School Certificate level.

Consider a 3rd form of 100 students with a mean score of 60% on an IEA test. If another 10 students who all score $\leq$ 5% are added to this group, the overall mean is reduced to less than 55%; if 20 students all scoring $\leq$ 5% are added, the mean is reduced to less than 51%. Possibly, this factor — a very high proportion of extremely low achievers — is responsible for our poor performance reported by the IEA in [4], and for the declining standards in PAT tests [8] widely publicised in the media recently. As the 7th form result indicates, maybe first-year University

Table 2

Highest Academic Qualification of Potential Workforce (1981)

Percent	Tertiary	Bursary or S/ship	SF Cert or UE	3 or 4 SC passes	1 or 2 SC passes	None	Other
Female	16.6	2.6	8.3	8.7	4.8	53.8	5.2
Male	22.9	3.6	8.3	7.2	3.9	49.7	4.4

Source: Department of Statistics Census of Populations and Dwellings, cited in *Profile of Women* [7].

mathematics students do not share the same decline in standards (approximately 12% of all pupils leaving school will enrol directly at University), but no formal research has yet been done in this area.

My concern for the 'underachiever' is addressed further in the section on Remedial Mathematics.

Table 3

Percentage of school leavers (1985) completing:

	Form 5 or less, no SC passes	Form 5, with one or more SC pass	Form 6	Form 7
Female	30	23	32	15
Male	36	22	26	16
Total	34	22	29	15

Source: *Education Statistics of New Zealand 1986* [9].

Table 4

Percentage of Students Taking Mathematics

(at Form 6, out of those taking English; at Form 7, out of the entire group)

		1976	1979	1982	1985
Form 6:	Females	58	64	70	70
	Males	86	86	87.5	86
Form 7:	Females	58	56	56	56
	Males	78	77	76	76

Source: *Science Education in New Zealand: Present Facts and Future Problems*, M. Clark and D. Vere-Jones [3]

Forms 6 and 7

As we can see in Table 3, a sizable proportion of the school population leaves from these forms.

If we consider only pure mathematics courses, a majority of senior pupils do choose to study mathematics, although there are quite a number of options available at this level (Table 4). The proportion taking mathematics has been reasonably stable for some years.

One aspect of this senior secondary school group which should concern us is the 'shrinking proportion of boys taking traditional science combinations' noted in [3], particularly with regard to the carry-on effect this may have on the numbers choosing to do mathematics at tertiary level.

The recent changes, with the removal of the University Entrance Examination from the sixth form and new syllabi in the seventh, mean that the senior secondary school is comparatively well catered for, particularly if Bursary Examiners choose to reflect the practical nature of the new 7th form syllabi in their examinations.

The most urgent need at this level, according to teachers, is for more resources, particularly for the ready availability of Teachers' Guide Notes, adequate textbooks and the opportunity for teachers to bring themselves up-to-date (with syllabus changes, say) through refresher courses and the like.

(ii) Attraction of Students —

— Across Cultures:

Two politicians have stated publicly that Maoris will need to be numerate and trained in modern technology, if they are not to be condemned to a life of peasantry (Peter Tapsell, in the Evening Post, 18 May 1987, and Simon Upton, at the Association of Scientists seminar on 15 May 1987). Most Polynesian cultures traditionally had a decimal-based number system, but numeracy in the modern sense is not rated as highly as in European cultures. How do we make mathematics a relevant and attractive option for Maori and other Polynesian groups?

— Across Genders:

There is evidence of gender differences in performance in mathematics in New Zealand. Both Claire Stewart [10] and Helen Wily [3] are in general agreement with a recent British study which suggests that these differences begin as early as age 11. See *Girls and Mathematics*, The Royal Society and The Institute of Mathematics and its Applications 1986 [11]:

> 'There is no convincing or conclusive evidence that it can be adequately accounted for by an innate or genetic disability at mathematics in girls. Consideration is given to various influences, in particular the image of mathematics in schools, girls' self-perception (their attitude to themselves and to mathematics), and their interactions with, and the expectations of, their teachers, parents and peers. Teaching styles, methods of classroom interaction, the examination syllabus and modes of assessment are also influential.'

While girls in New Zealand do seem to be participating more, and there are now approximately equal numbers of both sexes in the 6th form [12], 'it is evident that girls passing into forms 6 and 7 still take a different spectrum of subjects from the boys, with considerably fewer taking mathematics' [3]. B. Reilly and others, *Gender Differences in Performance in Bursaries Pure Mathematics*, [13] also found evidence for differences in performance at 7th form level between boys and girls attending co-educational schools in particular. Women account for by far the largest percentage of returning adults at all levels in the education system. According to the Royal Society report [11], we have to research new teaching techniques, alter existing textbooks and possibly drop some methods of examining altogether (for example, multi-choice questions), before we can begin to claim that we are making mathematics attractive to women. However, it is women (and these generally without a strong background in mathematics) who constitute the majority of teachers in the attitude-forming primary years (Table 5)

Table 5

Percentage of Females among Teaching Staff

Nature of Institution	Percentage of Female Staff
(as at 31 May 1985)	
Kindergarten	99
Primary —	71
Principal	14
Deputy Principal	33
Senior Teacher Juniors	89
Secondary	49
Training College	34
Technical Institutes	31
(as at 1983)	
University	14
Full Professor	3
Professor of Mathematics	0

Sources: *Position of Women in Education, 1985* [14] and *Profile of Women* [7].

(iii) Remedial Mathematics

The 'Beattie Report' [1] recommends that curricula 'be designed to meet the needs of the population as a whole for living in a knowledge-based industrial age' and that 'longer secondary schooling' be possible while 'Government rapidly increase the availability for post-secondary technological training for certificated school leavers irrespective of sex, age, level of certificate or location, and for those already in the workforce'. This, together with the Curriculum Review [5] recommendations that 'provision be made for catch-up classes in mathematics for senior students' and 'positive programmes be developed to ensure that Maori girls reach high levels of achievement and are encouraged to enter a wider range of occupations and professions' means that there will be an increased demand for remedial 'basic skills' mathematics.

From my own experience of teaching basic skills to first-year University students [15], techniques that work well with adults are a dismal failure when tried on 5th form students, and I suspect that the reverse is true. Have we sufficient teachers to cope with this new demand?

(iv) Dealing with the Teacher Shortage

There is now wide acceptance of the fact that there is a chronic shortage of mathematics teachers. According to the 1986 Subject Staffing of State Secondary Schools [16], 17.7% of all short-term relievers were teaching mathematics. Of schools unable to recruit staff, the highest number (79) required mathematics teachers. Concerns about the mathematical qualifications of these teachers have been expressed by M. Clark in *Basic Skills — Who's Guilty?* [17] as early as 1984 and again by myself in 1986 [18].

This shortage will only be alleviated by:

(i) recruitment — changing training college criteria so we can get more suitably qualified mathematics teachers (selection panels need to be aware of the importance of having at least one specialist mathematics teacher in every primary and secondary school),

(ii) retention — keeping the teachers we have (most do an excellent job under adverse conditions) — improving teaching conditions (smaller class sizes, reduced time in front of classes, more paid opportunity for refresher courses, better availability of resource material, and so on), and

(iii) training non-specialist teachers to teach mathematics.

While the last suggestion is not a perfect solution and could be seen as counter-productive, it may be the only viable one in the short-term. It could be reasonably successful if we were to make use of the skills that some of the tertiary institutions (especially polytechnics) have developed for the remedial mathematics teaching of returning adults. There is an urgent need for the government to set up some such scheme, instead of leaving the situation to proceed haphazardly towards disaster.

Conclusions

Almost everything I have suggested will involve more research, new courses, retraining programmes, and the like. I am well aware that all of these need substantial amounts of money, and I believe that not only should the government start providing this immediately, but that it is our job, as the mathematics professionals, to convince the government of the urgent need to provide such money for mathematics education in this climate of ever-increasing and competitive demands. Currently only approximately 0.1% of the total education budget is allocated to research [1].

The universities themselves need to give research in mathematics education a higher profile, particularly that undertaken by mathematicians. This type of research may ultimately be of more benefit to the public perception of our subject than the traditional research which adds only to our 'pool' of mathematical knowledge.

References

[1] **The Beattie Report** *Key to Prosperity, Science and Technology, Report of the Ministerial Working Party*, The Report of the Ministerial Working Party on Science and Technology, November 1986, Wellington.

[2] M. Clark and D. Vere-Jones, *Science Education in New Zealand: Present Facts and Future Problems*, Technical Report Series, January 1987, Institute of Statistics and Operations Research, Victoria University of Wellington, Wellington.

[3] H. Wily, *Women in Mathematics: Some Gender Differences from the IEA Survey in New Zealand*, NZ Mathematics Magazine **23**.2, 39–49, 1986.

[4] **The IEA Report** *Mathematics Achievement in New Zealand Secondary Schools. A Report on the Conduct in New Zealand of the Second International Mathematics Study within the International Association for the Evaluation of Educational Achievement*, Department of Education, Wellington, 1987.

[5] *The Curriculum Review 1986. A Draft Report Prepared by the Committee to Review the Curriculum for Schools*, Department of Education, Wellington, 1986.

[6] *Mathematics Syllabus Review, Forms 5 to 7, Discussion Papers #1, #2, Progress Report*, Department of Education, Wellington, 1987.

[7] *Profile of Women*, Department of Statistics, Wellington, 1985.

[8] A. Gilmore and N. Reid, *PAT: Mathematics Tests 1985. Check on Norms and Items. Research Report to Advisory Committee on Education Tests*, New Zealand Council for Educational Research, Wellington, 1985.

[9] *Education Statistics of New Zealand 1985, 1986*, Department of Education, Wellington.

[10] C. Stewart, *Sex Differences in Mathematics*, Research Report Series **4**, Department of Education, Wellington, 1986.

[11] *Girls and Mathematics. A Report by the Joint Mathematical Education Committee*, The Royal Society and The Institute of Mathematics and Its Applications, London, June 1986.

[12] D. Vere-Jones, *On Recent Changes in the Mathematics Curriculum in New Zealand Upper Secondary Schools, Mathematics Education*, 35–37 in *Stochastic Processes and their Applications, Fifteenth Conference*, Nagoya, Japan, 1985.

[13] B.J. Reilly, I.L. Reilly, J.R. Pemberton and A.J. Lee, *Gender Differences in Performance in Bursaries Pure Mathematics*, NZ Mathematics Magazine **24**.1 (1987), 19–23.

[14] M. Donn, *Teacher Career and Promotion Study. The Position of Women in Education 1985*, Department of Education, Wellington, 1986.

[15] S.D. Forbes, *Who Needs Basic Skills?*, The New Zealand Mathematical Society Newsletter **31** (1984), 17–23, Wellington.

[16] *Subject Staffing of State Secondary Schools*, Education Department, Wellington, 1986.

[17] M.J. Clark, *Basic Skills — Who's Guilty*, The New Zealand Mathematical Society Newsletter **31** (1984), 12–16, Wellington.

[18] S.D. Forbes, *Statistics in Our Schools — For Good or Bad?*, The New Zealand Statistician **21**.2 (1986), 24–30, Wellington.

Sharleen D. Forbes,
Wallaceville Animal Research Centre,
Ministry of Agriculture and Fisheries,
Private Bag, Upper Hutt.

Remedial Programmes

Some years ago, in Newsletter **31** (August 1984), Sharleen Forbes described the (remedial) problems at Vic and the programmes devised to palliate them. I make no apology for returning to this theme. Waikato University has begun to acknowledge the problem and to look for answers: at the Colloquium in May, Fay Sharples and Heather Gardiner spoke about their work — read on.

Editor.

The Basic Mathematical Skills Programme at Waikato

Fay Sharples
Waikato University

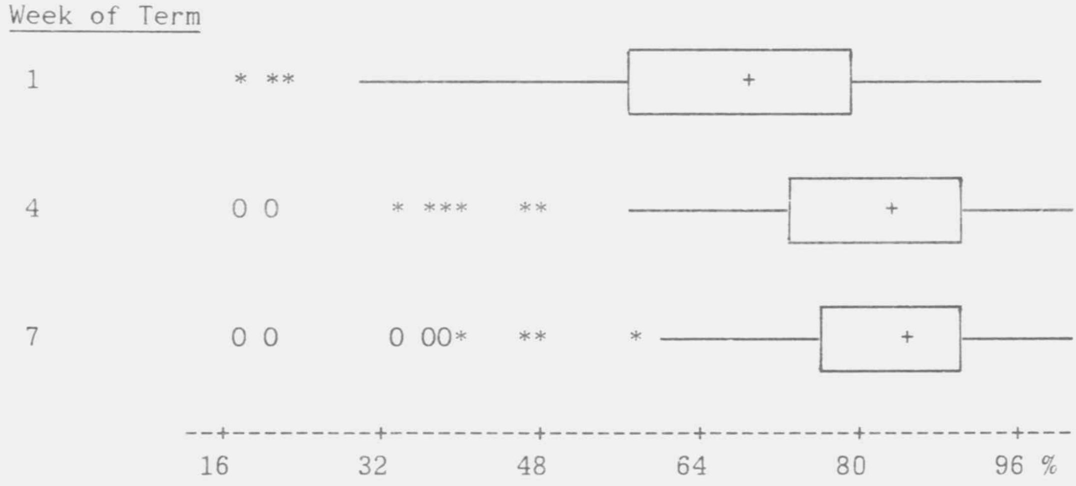
This programme helps students in the course 23.111 *Introduction to Statistics A*, which they enter with mathematical backgrounds varying from no High School mathematics to Form 6 and/or previous University mathematics. For some years we have been evolving a programme to build up their understanding of and skills in elementary mathematics (that is, form 5 or less).

In the first week, students sit a diagnostic test in three sections: **arithmetic, algebra and statistics.** They follow this with computer–aided instruction in the areas of their weakness. Two mastery tests are given at intervals of three or more weeks to evaluate their progress. Students aim to achieve 'mastery' (75–80%) in each of the three sections.

Mastery status is the weighted sum of a student's best performance on the three sections of the tests, namely, arithmetic from the diagnostic test, algebra from the second mastery test and statistics from the first mastery test.

Shown below are the boxplots of mastery status at the diagnostic test and after each mastery test. Only about 25% of the class have mastery of these basic skills at entry, but this percentage rose in 1986 to about 70% at the end of the programme.

Student's Mastery Status at Weeks 1, 3 and 7 in 1986.
All students present for the diagnostic test are included



In 1986, the relationship between mastery status and attainment in the course was investigated by following progress to the end of the year. In these tables, the category 'gave up' includes students who withdrew formally in week 2 through to those who completed most of the coursework but failed to sit the final exam. About half of them withdrew, and the others had an X.

Mastery status: Week 1 Score	N	Gave up	Failed	C Pass	B- or above	Pass rate as a %age of those in the group
10 – 49	14	13	0	0	1*	8%
50 – 59	18	5	5	5	3	44%
60 – 69	31	10	3	5	13	58%
70 – 79	28	6	6	6	10	57%
80 – 99	22	1	2	5	14	86%

Mastery status: Week 7 Scores	N	Gave up	Failed	C Pass	B- or above	Pass rate as a %age of those in the group
10 – 49	8	8	0	0	0	0%
50 – 59	1	1	0	0	0	0%
60 – 69	10	9	1	0	0	0%
70 – 79	21	6	5	5	5	48%
80 – 99	73	11	10	16	36	71%

Of the original group, no student with mastery status below 70% passed the course (in fact, only one sat the final exam). However, many students improved their basic mathematical skills considerably during the 7 weeks of the programme and, even if not successful in the course, may have gained confidence in using such skills.

This year, 1987, the University appointed a Study Skills Advisor in basic numerical skills (Heather Gardiner), to help students in **all courses** with difficulties due to gaps in their mathematical background. This year too, the diagnostic testing was extended to 05.107 *Basic Mathematics.* The results for Social Science students in 23.111 and 05.107 who sat the diagnostic test are given below:

Score	**N**
10 – 39	15
40 – 49	11
50 – 69	14
70 – 99	28

This suggests that at least 26 Social Science students in these two classes may need extra help, while 28 are comparatively well prepared.

* An overseas student who scored 47% on the diagnostic test and 96% on the first mastery test.

The Basic Numerical Skills Programme

Heather Gardiner
Waikato University

The Basic Numerical Skills Programme mentioned above was set up in February this year, as a one-year pilot study to determine the extent of the demand for such a service.

During Term 1, 'customers' could consult me three days a week from 1.00 to 3.00 pm, and in Term 2, I offered a Structured Workshop in Basic Algebra on Wednesdays as well.

Customer Profiles

Numbers Seen:

Total	Female	Male	? — see below
49	26	8	15

They Came From:

Economics	Mathematics	Psychology	Chemistry	Biology	Geology
27	15	18	2	2	2

Highest Level of Their Previous Mathematical Experience:

Primary	Core	Form 3	Form 4	Form 5	Form 6	Form 7	?
1	3	2	8	7	7	6	15

Gap Since Their Last Formal Mathematical Experience:

None	1–10 Years	11–20 Years	21–30 Years	31–40 Years	41–50 Years	?
6	11	12	2	1	1	16

Notes

Several customers had problems from various areas — this explains the overlap seen in the second row.

The "?" entries in these tables occurred because of an influx of anxious students from 15.102 *Microeconomics* in week 1, while I still did not know what data to collect. Most of these had done 5th or 6th form mathematics and seemed happy after a revision lesson on the straight line (which had been presented to them in an unfamiliar form). Those with more serious problems came back later. After that, I saw students in small groups or one-to-one, as they appeared. In general, I have no way of knowing how successful I was — the only positive information I have is that the University Bookshop had at one stage sold out of the suggested book, *Basic Skills in Mathematics,* by Sharleen D. Forbes.

Most of the Mathematics students were from 23.111 *Introduction to Statistics A*, which provides some help with remedial mathematics, and these students were usually taking Economics as well. The Psychology students came mostly in response to a diagnostic test in 18.103 *General and Experimental Psychology;* they were in general pleasingly keen to gain confidence and facility in mathematics.

The small number of students from Science seems to indicate that those in need of a service may not use it, even when urged to do so.

Some students, particularly mature students intending to do Economics, do not get a sufficiently clear message that a **good** understanding of School Certificate algebra at the very least is needed for just about every course with any mathematical or statistical content.

Few students can make up for a poor mathematics background **at the same time** as attempting a full load of University courses (some of which need the missing mathematics). This may explain why many customers did not return to ask questions or to tell me about their progress. **People learning mathematics must commit time to doing mathematics!**

New Start programmes could direct potential students to a Basic Mathematical Skills Workshop. This should take place some time before enrolment, possibly October to December of the previous year. Some would be well advised to defer University enrolment for a year, and attend the School Certificate mathematics courses already available in the community.

Other students (say, those with a few gaps in an otherwise adequate mathematics background, or those who've been away from mathematics for some time) also need some advice and help. However, their problems seem solvable within the teaching year, and take up a great deal less time.

Book Review

I need copy: I have books for review, I have space in the N/L ... The rest is up to you!

John Clark,
Reviews Editor,
Otago University.

Constructive Combinatorics, by Dennis Stanton and Dennis White; Undergraduate Texts in Mathematics, Springer-Verlag, Berlin – Heidelberg – New York – Tokyo, 1986; x + 183 pages, 73 figures, bibliography, index; ISBN 3-540-96347-2; hard cover, price DM 48.00.

Constructive Combinatorics is an unusual and interestingly conceived book. It is intended to be used as a textbook for a second course in combinatorics at an advanced undergraduate or postgraduate level, in a situation where an advanced course on graph theory is either not required or is available separately. Thus graph theory is, for the most part, conspicuous by its absence. The theme of the book is combinatorial algorithms, hence the title — and hence also the unusual nature of the book, for while other books discuss these algorithms, this is the first combinatorics text I have come across in which algorithmic ideas are so carefully woven into the whole fabric.

The book contains just four chapters, each based on a single unifying concept. Chapter 1 introduces five basic combinatorial objects — permutations, subsets, integer partitions, set partitions and product spaces. Algorithms are given for listing those objects, as well as for finding where a given object appears in the list, and conversely: ranking and unranking, in the authors' terminology. The algorithms are carefully explained and used to obtain several interesting representation theorems.

Chapter 2 gives partial orderings for each of the five objects introduced earlier. This provides the context for a discussion of rank, independence and chain decompositions in posets, followed by a section on extremal set theory devoted mainly to proving the Kruskal-Katona theorem.

The theme of Chapter 3 is the application of bijections to various combinatorial problems. For example, bijections between six sets are described, and used to show that all these sets are counted by the Catalan numbers. The Prüfer code for labelled trees is given by means of an algorithm, and used to prove Cayley's theorem and other results. After a discussion of various bijections involving integer partitions and permutations, there is a substantial section devoted to standard tableaux, centred on the Schensted correspondence between permutations with repetitions and pairs of standard tableaux (including of course, appropriate algorithms).

The final chapter is concerned with involutions on signed sets. These are used to prove the inclusion—exclusion principle, the Euler Pentagonal Number theorem, Vandermonde's determinant (interpreted as a generating function for tournaments), the Cayley-Hamilton theorem, the Matrix-Tree theorem on the number of spanning trees of a labelled graph, and some results on lattice paths. The chapter and the book conclude with an algorithmic presentation of the Garsia-Milne involution principle for constructing signed bijections, with some applications.

What else needs to be said? The algorithms (21 in all) are listed in the body of the text using an abbreviated form of Pascal (more complete Pascal programs are given in an appendix). However, it is not necessary to be familiar with Pascal in order the read the text. This reviewer can confirm the authors' comment, that all that is required is some familiarity with any programming language. The main prerequisite of the reader is that desirable but elusive quality, mathematical maturity.

There are a large number of exercises, graded into four categories of difficulty. They encourage the reader to use algorithms to explore and experiment, and to make and prove conjectures. As well, some exercises ask for programs to be written. In general, this is very much a book to be worked through rather than simply read or referred to (although the listings of algorithms might be a useful reference). A handy computer, while not essential, would undoubtedly make the journey through the book more interesting and rewarding.

The text was produced using a micro-computer and laser printer, and the result is pleasing to the eye. I noticed only a few trivial misprints.

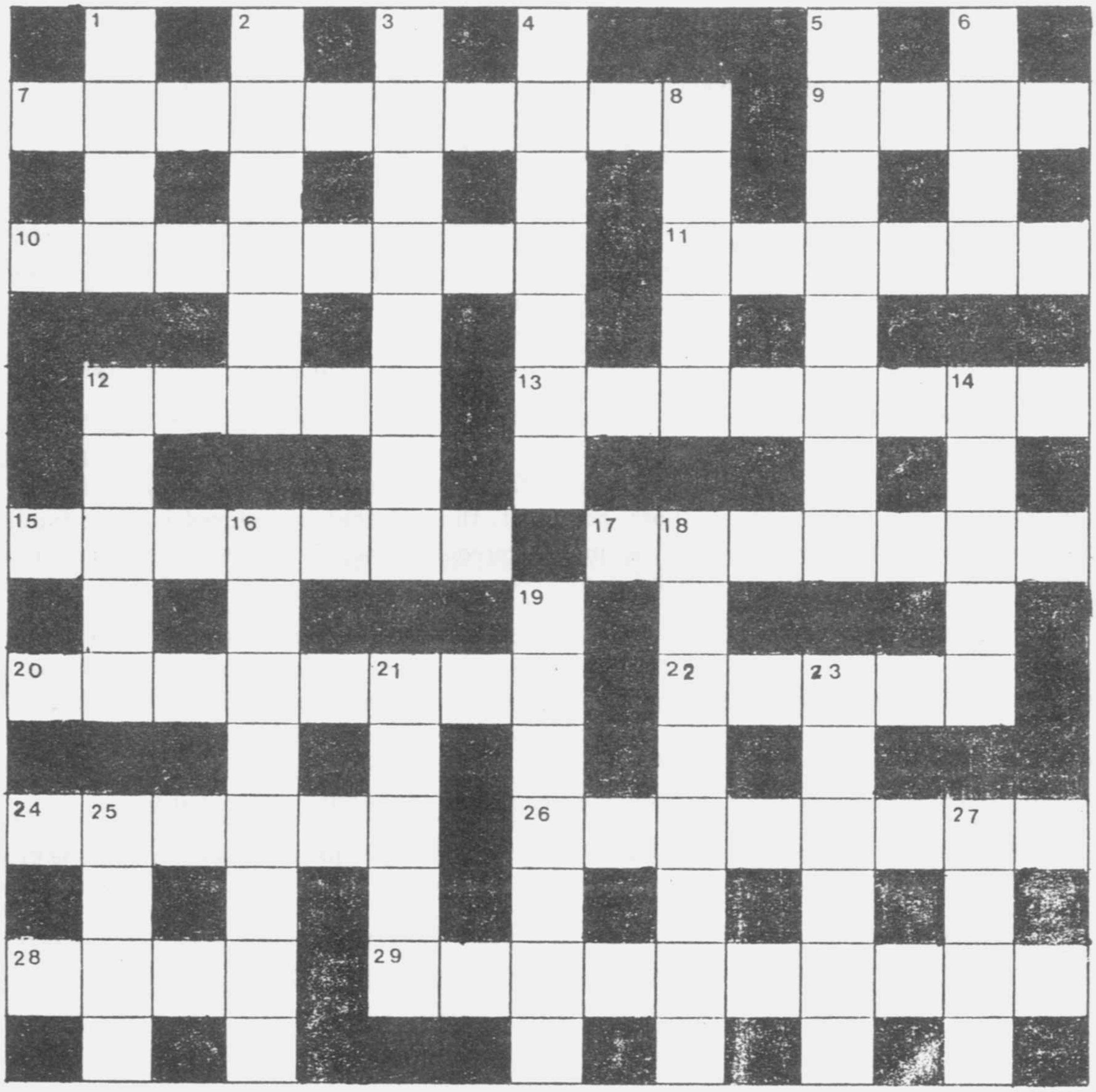
Certainly, a book worth having on the library shelves: it might make some converts to combinatorics! And if you are planning an advanced course in combinatorics, the approach used by Stanton and White is well worth your consideration.

MR Carter,
Massey University.

Crossword

22 — A Solid Education

by Matt Varnish



Across:

7. Can the door be one of the regular five? (10)
9. Forster's had a view but Woolf's was her own. (4)

10. Mary dips into the oldest of seven. (8)
11. The western limits are jamming solids. (6)
12. Like a halo from our saint? (5)
13. Mare and bull collapse into manifold raised above. (8)
15. The bloke is turned to Egyptian stone. (7)
17. With four points the colt takes the rap. (7)
20. Cry 'lined!' for the generators of this solid. (8)
22. Solid centre with the right insert (good for a hundred lakhs?) (5)
24. The most perfect solid around? (6)
26. Manmade approximation to 24 is a metaphorical increase. (8)
28. Solid whose dual is elsewhere. (4)
29. The art of geometry for astronauts? (10)

Down:

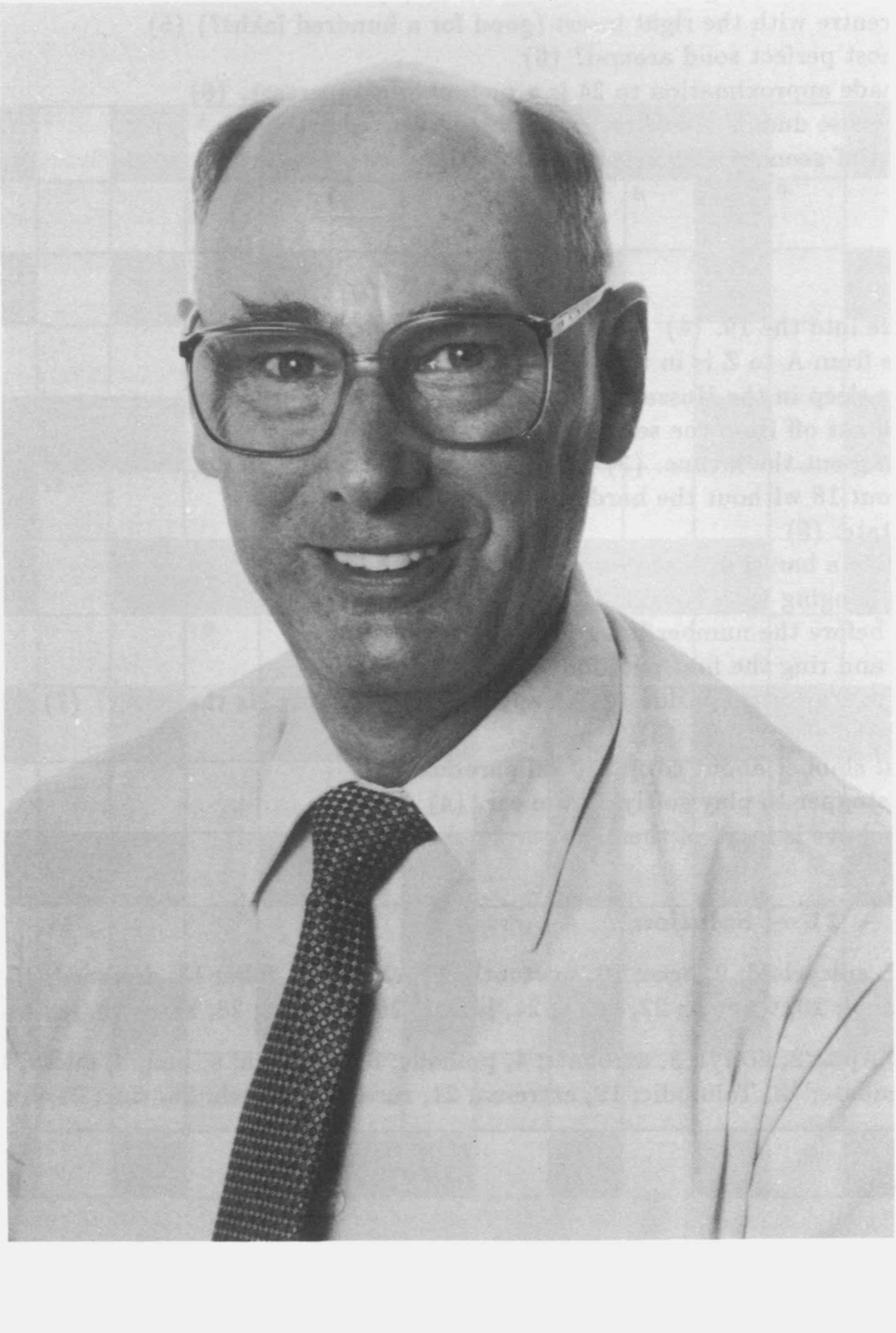
1. To gaze into the 19. (4)
2. Where from A to Z is in an arab muddle? (6)
3. See Sis sleep in the Hussar's jackets. (8)
4. A solid cut off from the sea thrown upon the belly. (7)
5. Treading out the incline. (7)
6. Its about 18 without the hard part. (4)
8. Potentate. (5)
12. Solid like a barrel or just plump? (5)
14. Freely hanging with nothing inside to misplace. (5)
16. See it before the number hung about. (8)
18. Fixed and ring the first part for 12. (8)
19. Weep to start stray inside with 1 aptly to the forefront. Is that clear? (7)
21. Each needs two to do. (5)
23. Almost slobber about cosmological paradox. (6)
25. Show stopper to play softly on the ear. (4)
27. Space above is in all of them. (4)

Crossword — 21 — Solution

Across: 7, epicycloid; 9, ogee; 10, sawtooth; 11, circle; 12, folia; 13, designed; 15, ellipse; 17 ctenoid; 20, tractrix; 22, locus; 24, isobar; 26, roulette; 28, knot; 29, lemniscate.

Down: 1, Apia; 2, acetyl; 3, acrobats; 4, polhode; 5, Corrigan; 6, bell; 8, ducks; 12, filer; 16, incubate; 18, Talmudic; 19, extrema; 21, rural; 23, clench; 25, sine; 27, tote.

Centrefold



Professor Achim (Teddy) Zulauf

Emeritus Professor Achim (Teddy) Zulauf

by John C Turner
University of Waikato

Professor Zulauf was invited to the Chair of Mathematics at the University of Waikato in 1969, when Professor Desmond Sawyer resigned in order to return to the University of Otago. When Teddy Zulauf took over the Department, the University itself was but four years old, so the Department was very small, staffed by two or three pure mathematicians. Then, when the School of Science first opened its doors to students in 1970, new staff had to be appointed. Teddy Zulauf planned to develop Mathematics across a broad band of topics, and in his first year, appointed Readers in Mathematical Physics and Statistics to help him do it. From these beginnings, the Department grew rapidly to one of some fifteen staff, dealing with over 1600 student-courses for students in five Schools. With characteristic fairness, thoroughness and untiring energy, Teddy presided over this development, and saw to it that the teaching of mathematics proceeded smoothly and well in all Schools and all areas.

Teddy took out his first degrees at the University of Mainz, in Germany, shortly after the Second World War: a B.Sc. in 1948, an M.Sc. (with distinction) in 1950, and a Doctorate of Science (magna cum laude) in 1951. His supervisor for the D.Sc. was H.H. Rohrbach, a disciple of E. Landau; and he was the first student to receive the degree after the University was re-established after the war. His early research interest was in Analytic Number Theory, especially problems involving prime numbers. Working on these problems under supervisor H. Davenport, he completed by thesis and oral the requirements of a Doctorate of Philosophy at the University of London in 1958.

In 1952, he went out to the University College of Ibadan, Nigeria. It was to be an appointment for only one year, but it continued for eight. The College was founded in 1948, in special relationship with the University of London, so when Teddy joined it, it was in its third year of operation and still housed in army barracks. F.V. Atkinson was then the Professor of Mathematics. When Teddy left in 1960, the College occupied a magnificent modern campus, and its international reputation was becoming established. In 1962, it became the University of Ibadan, one of 24 Universities in Nigeria, and now it has 10,000 students, including 3000 postgraduates, and a staff of 30 in Mathematics and Statistics, including 5 Professors and 5 Readers.

This was the first University that Teddy Zulauf helped to develop, almost from its beginning. The second was the University of Sierra Leone. In 1827, Fourah Bay College was established on the coast in Freetown, Sierra Leone, as a theological college. It was affiliated to the University of Durham in 1876 (Freetown became known as the Athens of West Africa), and in 1960 it received the Royal Charter as an independent University institution in special relationship with the University of Ibadan. The Faculties of Science and Applied Science were then established, and Teddy was the first Professor to be appointed. And so, still but 34, he took over the job of Head of Mathematics, with the general task of helping to build a new University, in a British Colony which was to obtain its independence one year later. He held the post for eight years before coming to New Zealand, and during that period, held many high offices in the University (Dean of Science, Member of Council, Member of Senate, and so on).

And so it was that Teddy Zulauf, who from a boy had wished to be a Professor of Mathematics, achieved his career wish at an early age, and for 25 out of his 35 years as a university academic, headed Mathematics Departments and helped guide his Universities through their formative periods.

Notwithstanding the heavy administrative loads that Teddy has borne, he has always carried out a full share of teaching, and produced a steady stream of research papers as well. His teaching experience spans all levels from service courses to doctoral thesis supervision; he has always had a strong interest in curriculum development and teaching methods. His research was based on a long-term project to investigate Riemann's hypothesis, a task which had defeated many mathematicians before him and which has defeated him too, so far — the hypothesis remains for others to prove or disprove. Alongside this very difficult project, his interests range widely in pure mathematics: his published research deals with inequalities, pre-orderings, generalised integers, analytic functions, and many minor problems with an algebraic or geometric flavour. He has presented his work at numerous conferences, national and international; he has often refereed papers in number theory and complex analysis. He enjoys his mathematics, as the articles, problems and problem solutions contributed to popular publications such as the Mathematics Magazine show, and he has always encouraged teachers and students in their study and enjoyment of mathematics.

In 1986 Teddy decided to stand down from the headship of the department, and after a one-year handing-over period, he decided to retire altogether, just sixty. The University marked his long service as an academic administrator and his international repute by appointing him an Emeritus Professor of the University.

Teddy intends to continue his research in mathematics, and we look forward to seeing him, whenever he visits the Department. We hope that he will enjoy a long and happy retirement, together with his wife Trudi, who has been by his side through all the years of 'University building'. At last, they have unlimited time to spend together on hobbies such as bridge and gardening, and on trips to their bach at Pauanui !

Local News

Junior Mathematics Competition

The **National Bank Junior Mathematics Competition** was held in April and attracted more than 5000 entries from over 150 schools — 1987 3rd formers, 1680 4th formers, and 1407 5th formers. This competition was based at the University of Otago and is the brainchild of Professor Holton, who was the convener as well as 'co-organiser' with David Hill, John Curran, and John Rayner.

The prize- and award-winners will have their awards presented in the various local centres in late July. The organisers have generally been very pleased with the performance of the contestants.

The **first prize winners** in Form 3, 4 and 5 were, respectively,
Ashley Chan from Auckland Grammar,
James Foulds from Christ's College, and
Reuben Barclay from MacLeans College.

Further information regarding this competition can be obtained from Dr David Hill, University of Otago.

Waikato University

Mathematical life returned to its normal steady pace following the Mathematics Colloquium — though the after-effects continue! Murray Jorgensen and Graham French are steadily resolving the outstanding problems, mainly practical ones.

Roger Hosking attended the 1st International Conference on Industrial and Applied Mathematics at INRIA in Paris and presented a paper entitled *Wave Motion of Ice-Covered Seas.* He also visited colleagues in Washington.

Ernie Kalnins had a fruitful a visit from his ex-student Greg Reid, now mathematically active at the University of British Columbia and working on symmetries for partial differential equations with George Bluman.

Ian Craig visited his collaborator Sandy McClymont at the Institute for Astronomy in Honolulu. Recreational activities in Hanama Bay provided him and his family with aquatic delights as an antidote to modeling solar flares.

Saunders Mac Lane's visit gave rise to an irregular working seminar series on Toposophy. Professor Krishnamurthy from Computer Science gave us three talks about categories and universal algebra, in the context of the logical structure of algorithms. Mark Schroder explained why *Fuzzy Sets are not Fuzzy Enough*, and gave a Kock-book introduction to synthetic differential geometry.

John Butcher and a group of staff and students with an interest in numerical analysis and computing from Auckland University visited the Mathematical Software Project in the department, and discussed matters of mutual interest deep within the symbolic–numeric interface. Talks and demonstrations were given on symbolic computation (Waikato), symbolic differentiation (Auckland), symbolic–graphical interfacing (Waikato), and numerical ode–solving (Auckland). The workshop concluded with a discussion on whether the Auckland code (STRIDE) could be interfaced to the Waikato symbolic system (SENAC). Answer — in principle, yes.

John Turner, Roger Hosking and Bill Rogers (Computer Science) visited Auckland, Massey and Victoria Universities, presented the University's plans for a new degree in Computing and Mathematical Science, and participated in well-attended and active discussions on related issues.

We welcomed two new secretaries, Juliet Harman from UBIX, and Janet Smith, indirectly from Chemistry. Both are doing excellent work mathematical typesetting using Mass11 and IBM systems. Philip Etheridge, our programmer–technician, has become a 'Campus Support Person' for both TEX and Troff. TEX can be previewed on the VAXstations and Troff on the Sun-3's, so typesetting is in great shape.

The Centre for Applied Statistics is providing a purposeful and significant addition to the life of the University and Department. Details on its activities may be found elsewhere in this or the next newsletter.

Seminars

Prof EC Zeeman (Warwick) *Stability Using the Fokker-Planck Equation*, *Determinacy of Germs*, and a well-attended public lecture, *Introduction to Catastrophe Theory, with Applications to Science and Medicine.*

Dr HE Huppert (Cambridge) *Dynamics of Volcanic Eruptions.*

DR Waugh (Grad Student, Waikato) *Visco-Elastic Effects on Flexural Ice Waves.*

Dr TR Robb (Waikato) *An Introduction to String Theories.*

Prof CG Broyden (Essex) *A Critical Review of Constrained Optimisation Methods.*

Prof E Gudkin (USC, Los Angeles) *Quantum Non-Linear Schrödinger Equation — Two Approaches.*

KAB

Department of Scientific and Industrial Research

Applied Mathematics Division — Wellington

A UNIX system has been installed at Palmerston North with its main application being the Bell Statistical Package S.

Alex McNabb and Graham Weir were jointly awarded a ministerial award for excellence in science at the Beehive on June 17.

Roderick Ball has been employed temporarily for 6 months at Mt Albert to assist with computing and statistics.

Robert Davies has returned from a visit to Australia where he attended and gave talks at the AMS annual meeting in Geelong, the Stats Conference in Melbourne and the RMIT.

Mark McGuinness, John Burnell and Roger Young attended the Geothermal Workshop in Auckland.

Selwyn Gallot, Graham Weir, Kit Withers and Jean Thompson attended the NZMS meeting at Hamilton.

Vicky Mabin has left for four months in North America to study production planning and inventory control.

Karen Garner has left temporarily, on one years maternity leave.

GJW

Applied Mathematics Division — Mt Albert

Roderick Ball has taken up a six months temporary appointment with us. He is a graduate of Canterbury (NZ) and Princeton Universities. Since completing his PhD in 1981, he has held positions at Princeton University, Purdue University, and New Mexico State University. His interests are in topology, linear optimisation, and parallel computing. Currently he is trying his hand at statistics.

Jocelyn Dale has taken six months leave from her work at the substation, but she continues her part-time lecturing at Auckland University.

JHM

COLLOQUIAL NOTES

Do you remember —

— Jean Pederson and Peter Hilton at the Colloquium dinner?

— when the President, Brian Woods, addressed the Colloquium dinner while the Secretary, Derrick Breach loyally took notes on the tablecloth, under the calm gazes of Peter Waylen and Derek Holton?

We thank Garry Tee for the photos.

University of Auckland

Theoretical and Applied Mechanics

Professor Robert Sowerby of McMaster University is visiting for two months as Fletcher Visiting Fellow. He is an expert on Metal–Forming Plasticity, and is working with Professors Collins and Duncan (Mech Eng). PhD's have been awarded for the theses of Andrew McCulloch, on *Deformation and Stress in the Passive Heart*, Margaret Blakeley, on *Geothermal Reservoir Modelling*, and Poul Nielsen, on *The Anatomy of the Heart: A Finite Element Model.* Andrew has a tenured appointment as Assistant Professor at UCSD, Poul has a Post Doc award at McGill, and we are still enjoying the company of Margaret. Julie Falkner and Andrew Pullan (research students) received grants from the NZMS and the RSNZ to attend conferences in Germany and Australia respectively.

The Department has a MicroVax 11 graphics workstation installed and working. Andy Philpott has developed MacSimplex, an interactive teaching tool for teaching Linear Programming.

Seminars

Prof Leonard Lewin (U Colorado) *Polylogarithmic Functions.*

Dr AB Philpott (TAM) *Continuous–Time Linear Programming* and *Continuous Network Programming.*

A/Prof DA Nield (TAM) *Effects of throughflow on the onset of convection.*

Dr HE Huppert (U Cambridge) *The dynamics of volcanic eruptions.*

Mr WB Mugridge (Comp Sci) *Expert systems.*

Dr W Schaap (Mining Eng) *Ore body evaluation formulated as an optimisation problem.*

Dr Ai Poh Loh (Elec Eng) *Estimation of uncertainty bounds for robustness analysis.*

Prof Gordon Foster (Trinity Coll, Dublin) *Development in Operations Research and Management Science since World War II.*

Dr David Lee (Data Sure Management Systems Ltd) *Surgery and systems.*

Prof R Sowerby (McMaster U) *Design aids for sheet metal stampings*

Dr J De Pont (AMD, DSIR) *Cyclide patches for Computer Aided Design.*

Prof Charles Broyden (U Essex) *A critical view of constrained optimization methods,* and *Skew-symmetric matrices, staircase functions and LP.*

DAN

Department of Computer Science

John Butcher has been elected to the Council of the Royal Society of New Zealand.

Dr Ian Thompson, of the Physics Department of Bristol University, is a graduate of the University of Auckland. He is currently a visiting lecturer in this Department and in our Department of Physics, giving postgraduate courses on parallel computation and on nuclear physics.

At the 1987 Mathematics Colloquium, John Butcher gave a lecture on *Order Stars*, and Garry Tee spoke on *Roger Cotes, 1682–1716.*

Garry Tee gave a lecture on *Computers and Mathematics* on March 25, as the first lecture in the 1987 Summer Lecture Series at the University of Waikato. He gave a lecture on *Early computing in New Zealand* at the Conference on the History of Statistics in New Zealand, held at Victoria University of Wellington on July 1.

Seminars

Dr Richard Thayer (California State University, Sacramento), *Software Requirements Specification.*

Dr William F Luebbert (Computer Literacy Institute, New Hampshire), *Quipus and the Management Information System of the Incas.*

Professor Peter J Brown (University of Kent at Canterbury), *Interactive Documentation.*

Dr Colin Beardon (University of Waikato), *Some Recent Trends in Natural Language Parsing.*

Dr Geoff Wyvill (University of Otago), *Recent Computer Graphics Research at Otago.*

Professor Phil Cox (Technical University of Nova Scotia), *Storage Management in a Prolog Compiler.*

Professor Gary Lindstrom (University of Utah), *OR-parallel Logic Programming on a Shared Memory Multiprocessor.*

GJT

Mathematics

Jan Jaworowski returned to Indiana in June, and Glenn Anderson departs soon, after a very successful sabbatical leave working jointly with Vaman. Glen and Vaman will give us a summary of their work in preparation for a special day of talks which they will present in Helsinki in August.

One of our temporary tutors, Dr Margaret Morton, has been appointed as a permanent senior tutor.

For the first half of the year, the Department was occupied with its review. The external members of the review coommittee were: Dr Ray Littler (Waikato Centre for Applied Statistics), Dr Alex McNabb (Applied Maths Division, DSIR), Professor Bernard Neumann (ANU, Canberra), Professor Allen Shields (Ann Arbor, Michigan), and Professor Tim Wall (Sydney). We expect to see their report by the end of August.

Like other Universities, we have had a stream of distinguished visitors in the past few months. As NZMS Visiting Lecturer, Professor Saunders Mac Lane presented a lecture in March called *Topos Theory: Logic Meets Geometry,* and then in April, the first Forder Lecturer, Professor Christopher Zeeman, visited us at the end of an exhausting tour — the walking stick lent him at Christchurch after Dunedin was by then superfluous! We added to his exhaustion by extracting three talks from him: *The Dynamics of Darwinian Evolution*, *Geometry and Perspective*, and *Differential Equations from Game Theory.*

Seminars

Prof Glen McPherson (U of Tasmania), *A Simple Approach to Describing Complex Experimental Designs.*

Prof Jan Jaworowski (Indiana U), *On Vectors, Frames, Grassman Manifolds and the Borsuk–Ulam Theorem.*

Prof Jean Pederson (Santa Clara), *The Pólya Enumeration Theorem.*

Prof Peter Hilton (SUNY), *The Euler Characteristic and Descartes Deficiency, An Escher Staircase of Groups,* and with Prof Pederson, *The Practice of Geometry and the Theory of Numbers.*

Prof Don James (Pennsylvania State — and formerly of Auckland), *Integral Quadratic Forms.*

Prof Peter Whittle, FRS (Cambridge U), *Restless Bandits.*

Dr Robert Davies (AMD, DSIR), *Integrated and Co-Integrated Processes.*

Prof Sören Illman (Helsinki U), *Actions of Finite Groups and Equivariant Whitehead Torsion.*

Prof Bing-gen Zhang (Shandong College of Oceanography), *Oscillation and Stability in a Non-Autonomous Delay Logistic Equation.*

DBG

Otago University

Professor Derek Holton was the New Zealand observer at the 28th International Mathematical Olympiad in Cuba.

Professor Bryan Manly attended the Second International Tampere Conference on Statistics in Finland.

Dr Gerrard Liddell attended the Apple Developer Conference in Canberra, Australia during June. This gave him a chance to see new mathematical software, to assess the Mac II for scientific computing and to make valuable contacts. He spent two days at tertiary institutions in Sydney, where the emergence of mathematical computing as a distinct discipline is a notable feature.

As a result of Professor Mac Lane's visit in February and March, we are having a Departmental Seminar on Category Theory, mainly with John Clark, John Harris, David Hill, and Gerrard Liddell.

Longer term visitors include Dr John Sheehan (University of Aberdeen, Scotland) who was here from May to July to collaborate with Professor Holton, and Professor Lyman McDonald (University of Wyoming) who is here from June to August to collaborate with Professor Manly.

John Rayner convened an Otago University Extension Course on *Essential Mathematics for Commerce and the Sciences* — based on Sharleen Forbes' book *Basic Skills in Mathematics.* Fifty-one students from various walks of life were enrolled — and John was assisted by a variety of tutors from the Department.

Professors Manly, Zeeman, Hilton, and Jean Pederson (University of Santa Clara) gave talks to the Otago Mathematics Association. Bryan spoke on *Objectivity in Statistics an*

Science; Christopher presented *On Mathematical Masterclasses,* Peter discussed some problems in mathematics education, and Jean gave a talk on geometric models.

Seminars

Professor Christopher Zeeman (University of Warwick — 1st Forder Lecturer), *Introduction to Catastrophe Theory, with Applications to Science and Medicine.*

Professor Michael Perlman (University of Washington), *Group-invariant Covariance Models.*

Dr H Huppert (University of Cambridge), *The Dynamics of Volcanic Eruptions* — jointly with the Geology Department.

Professor C Broyden (University of Essex), *A Critical Review of Constrained Optimisation Problems.*

Professor Branko Grünbaum (University of Washington), *Periodic and Aperiodic Tilings.*

Professor Peter Hilton (SUNY at Binghamton), *Group Operators.*

Dr Ron Aharoni (Technion, Haifa, Israel), *Matchings in Infinite Graphs.*

Professor Lyman McDonald (University of Wyoming), *Weighted Distribution Theory in Encounter Sampling.*

Dr Laimonis Kavalieris, *Estimating the Number of Parameters in a Model.*

GO

University of Canterbury

Mathematics

Bill Barit has returned from a year's study leave, spent mainly in the USA and the Netherlands. At the State University of New York, Buffalo, he worked with Ken Magill on semigroups of continuous functions, and at the Mathematical Centrum, Amsterdam, he worked with Albert Verbeek on statistical programs for analysing contingency tables.

John Deely travelled overseas during May and June to attend two conferences: first, the International Bayes Symposium at Blacksburg, Virginia, in honour of IJ Good's 70th birthday, and the second in Valencia, where he presented a paper and was an invited discussant at the Third International Valencia Symoisium on Bayesian Statistics.

We now find ourselves in a most unusual situation, certainly without precedent in the last fifteen years, in that no one is currently on leave. One result is that accommodation is at a premium. So far there is no 'double-up' by the twenty-seven academic staff, but with additional appointments pending, the situation is becoming critical.

Expected new arrivals will be partially offset by two impending retirements. Bob Long will retire at the end of September, after 35 years in the department, and John de la Bere will retire at the end of January, after 30 years.

Congratulations to Ingrid Rinsma on the completion of her doctorate, under David Robinson. She worked in graph theory, and her thesis is called *Existence Theorems for Floorplans.*

In September, she will move to Massey to take up a UGC postdoctoral fellowship in the Department of Mathematics and Statistics.

The department has had the pleasure of welcoming numerous visitors over the last three months, all of whom have contributed much by way of talks and informal discussions.

Seminars

Professor Christopher Zeeman (University of Warwick), *Geometry and Perspective,* and *The Dynamics of Darwinian Evolution.*

Professor CG Broyden (University of Essex), *Penalty Functions, a Comparison of Some Optimization Methods,* *Mark Scaling Algorithms,* and *Tucker's Theorem on Skew Symmetric Matrices.*

Dr HE Huppert (University of Cambridge), *Melting by Hot, Turbulent Flows.*

Professor Branko Grünbaum (University of Washington, Seattle), *Geometry of Ornaments.*

Professor Jan Jaworowski (University of Indiana) *On Vectors, Frames, Grassman Manifolds and a Borsuk–Ulam Theorem.*

Professor Peter Hilton (State University of New York, Binghampton), *New Algorithms in Number Theory,* and *Groups with Operators.*

Professor Jean Pedersen (University of Santa Clara, California) *Constructing Regular Polygons,* and *The Euler Characteristic and Descartes Deficiency.*

Professor Jim Berger and Professor Richard M Brumfield (Purdue University), *The Irrelevance of Stopping Rules in Statistical Analysis.*

In addition, several staff members have given seminars, as follows:

Neil Watson, *The Boundary Behaviour of Thermal Potentials.*

Peter Bryant, *The Spherical Pendulum.*

Robert Buill, *Offbeat Recursion Theory.*

Rick Beatson, *Bezier Representations, Parameteric Splines, etc.*

Allan McInnes, *Some Generalizations of Padé Approximation.*

David Wall, *Rank, Ill-conditioning and Inverse Methods — a Review.*

RSL

Electrical and Electronic Engineering

Dr W John Cocke, an astrophysicist from the Steward Observatory (University of Arizona at Tucson), is visiting as an Erskine Fellow, mainly because of his interests in image processing. While perhaps best known as co–discoverer of the first optical pulsar, John is active in mathematical aspects of astronomy (such as relativity and quantum theory). He remains here until December.

RHTB

Massey University

John Griffin recently joined us to strengthen the Operations Research side of our activities. For the last three years he has been Assistant Professor of Industrial Engineering at the University of Arizona in Tucson. Now John is looking forward to rekindling his enjoyment of the more mathematical side of OR, as well as developing links with the Faculty of Technology. John was born in Oamaru, raised in Blenheim and educated at the University of Canterbury. His PhD dissertation *Graph Theoretic Techniques in Facilities Layout* was supervised by Les Foulds. He has continued his research interests in facilities layout and location problems, and in heuristic and algorithmic graph theory generally. John's non-mathematical interests include science fiction and New Age and classical music; also he confesses to being a bridge fanatic and having a passion for *Star Trek*. He's glad to be back in Godzone, and we're delighted to have the pleasure of his company!

Doug Stirling has been developing a computer program, *StatLab,* for Macintosh microcomputers. Designed as a teaching aid in introductory statistics courses, *StatLab* can be used to teach basic statistical concepts by demonstrating the properties of summary statistics, confidence intervals, significance levels, and so on, under repeated sampling from populations. Alternative tests or estimators can be compared using such simulations, and *StatLab* can also perform basic statistical analyses of real data. *StatLab* is being used in lab-classes by 350 students in introductory statistics papers this year, and it will be published by Massey and the New Zealand Statistical Association in July. Doug is going on a year's overseas leave to Durham University in England at the start of August and intends to work with staff there in the area of computational statistics.

Greg Arnold is away at present, several months into a year-long sabbatical which will take him to Canada and the UK. Graeme Wake spent a week in Australia at the beginning of July, dividing his time between Macquarie University and CSIRO Division of Environmental Mechanics, in both of which places he is involved in collaborative work on combustion problems.

Sankara Kishore Kumar is expected soon, to take up a UGC postdoctoral fellowship. He will be continuing the work started by John Hearne on the modelling of ecological systems.

We have just learned that Robert Sisson, an MSc graduate of the University of Newcastle (UK), will be coming to Massey in 1988 on a British Commonwealth Scholarship to complete a PhD in mathematics. He will be working on the mathematical modelling of thermally reacting flows. This brings to six, the total of current PhD students in mathematics. (For many years, NZ postgraduate students have been gaining invaluable overseas experience in the UK and elsewhere — are we seeing the start of a reverse trend?)

Seminars

Dr CD Eccles and Prof PT Callaghan (Physics and Biophysics) *Microscopic NMR Imaging.*

Prof Saunders MacLane (Chicago), *The Rise and Fall of Abstract Mathematics* and *The Structure and Philosophy of Mathematics.*

Prof EC Zeeman FRS (Warwick) *The Dynamic of Darwinian Evolution Theory, Mathematics Masterclasses,* and *Differential Equations from Game Theory.*

Prof Gordon Foster (Trinity College, Dublin) *Reflections on Operations Research / Management Science since World War II.*

Dick Brook *Three Aristocratic Statisticans.*

Prof Jean Pederson (Santa Clara) and Prof Peter Hilton (SUNY) *Geometry in an Integrated Curriculum*, *The Geometry of Paper-Folding and Number Theory*, and *The Role of Discrete Mathematics in the Curriculum*.

Dr RJ Ball (New Mexico), *A Parallel Projective Method for Linear Optimisation*.

Dr John Reynolds (AMD), *Strange Tales from the Desk-Top Midden*.

Prof Brian Hayman, *Measure of Plant Aggregation*.

Prof Peter Whittle (Cambridge) *Restless Bandits -- Activity Allocation in a Changing World*.

Gordon Knight *Mathematics Achievement in New Zealand Secondary Schools*.

Doug Stirling *The Role of Microcomputers in Teaching Statistical Concepts*.

MRC

Victoria University

Prof Peter Whittle FRS, a former Victoria student and DSIR—AMD staff member, visited us briefly from Cambridge, UK, received an honorary DSc and gave seminars on statistical topics. (Further details of his career are Centrefolded in NZMS Newsletter **22**, Dec 1981.

Jim McGregor has been appointed Senior Lecturer in Meteorology. Congratulations! We await an appointment to his previous position of Fellow in Meteorology.

Rob Goldblatt was awarded the NZ Association of Scientists' Research Medal for 1985 for "outstanding research in the fields of natural, physical or social sciences by a person of less than 40 years of age". My apologies for not hearing about this sooner.

Bernard Flury has, alas, resigned. We shall miss him a great deal.

Tony Vignaux has returned from refresher leave in Berkeley and Warwick with a side trip to Beijing.

Terence Nonweiler has gone to Cambridge (Engineering Dept) on sabbatical. He is a Visiting Fellow of Wolfson College.

Ken Pledger is also on leave, in Wellington.

Jim Ansell is on the NZ National Committee for the Lithosphere.

John Harper is on the Council of the Royal Society of NZ as a member bodies' representative.

JFH

Information

1988 Australian Mathematics-in-Industry Study Group

Sydney, 1 — 5 February 1988

The fourth Mathematics-in-Industry Study Group will be held in Sydney from Monday, February 1, to Friday, February 5, 1988. The major sponsor of the Study Group is the CSIRO Division of Mathematics and Statistics and the principal co-sponsor is the Industrial Mathematics and Statistics Group of the University of N.S.W.. It is anticipated that about 20 industrial researchers and 70 professional mathematicians will attend the Study Group.

Goals

The Study Group is expected to be of benefit to all participants. In particular, its organizers aim —

i. to stimulate greater awareness in industry of the need for and role of mathematics,

ii. to establish better links between industry and professional mathematicians,

iii. to develop a better role for the Division of Mathematics and Statistics and the Industrial Mathematics and Statistics Group in industrial collaboration,

iv. to provide a fresh source of research problems for mathematicians,

v. to lead, ultimately, to better employment prospects for mathematics graduates, and

vi. to assist industries with problems requiring mathematical analysis.

Points to note

The **format** of the Study Group will be basically unchanged from previous years. On the first day, a selection of about 8–10 scientific problems of industrial origin will be presented by industrial researchers to the mathematicians. The mathematicians will then work collaboratively with the industry participants on the problems for three days before presenting their results on the final day. The Proceedings of the Study Group will be published, and a modest registration fee will be charged.

The **selection of problems** is the responsibility of the Director who will make extensive visits to industry in the months preceding the Study Group. The past 3 Study Groups have considered 26 problems from 17 separate companies. The range of problems studied in the past includes differential equation modelling, operations research, software design, computational problems, communication theory, and more. The applications have spanned Australian industry. The only necessary prerequisites for the 1988 meeting are that the problems should be of practical importance and amenable to mathematical modelling.

The **venue** for the Study Group has not been decided at this stage, although it is expected to be a college at the University of N.S.W.

The **date** for the Study Group is different from previous years. There are two main reasons for this change.

(i) The 1988 Australian Applied Mathematics Conference is to be held at Leura, about 100 km west of Sydney, during the week after the Study Group. There will be a saving on travel costs for many out-of-state delegates, now that the meetings are to be held on contiguous weeks.

(ii) Many academic mathematicians expressed dissatisfaction with the previous date of early December, as this clashed with academic examination procedures. We hope that the February date will be more convenient for them.

The **Proceedings of the 1986 Study Group** will be distributed to all members of the Division of Applied Mathematics of the Australian Mathematical Society as soon as possible (probably in June).

It is hoped to have some **New Zealand involvement** in the 1988 Study Group. This includes the presentation of possibly two problems from New Zealand industry, and participation by New Zealand mathematicians who intended to visit Australia for the Applied Mathematics Conference. Details will be availabe by the time the second circular is issued.

If you would like your name to be entered on the **mailing list for the second circular** to be issued in early November, please write to the Director at the address shown below. Don't forget to mention it, if you have any promising industrial contacts or problems. Fresh points of view are also welcomed.

Dr NG Barton, Director, 1988 MISG,
CSIRO,
Division of Mathematics and Statistics,
P O Box 218, LINDFIELD, NSW 2070;
Telephone – (02) 467 6702, (02) 467 6062.

Conferences

— 1987 —

September 3–7 (Kyoto, Japan)

Satellite Meeting to the 46th Session of the International Statistical Institute
Contact M. Huzii, Department of Informations Sciences, Tokyo Institute of Technology, O-okayama, Meguro-ku, Tokyo 152, Japan.

September 7–9 (Edinburgh)

Summer Conference on Category Theory and Computer Science
Contact D Pitt, Department of Mathematics, University of Surrey, Guildford, Surrey GU2 5XH, U.K.

September 7–11 (Luxembourg)

International Symposium on Harmonic Analysis
Contact J.P. Pier, Séminaire de Matématique, Centre Universitaire de Luxembourg, 162A, Avenue de la Faiencerie, L1511 Luxembourg.

September 8–11 (Kassel, West Germany)

Third International Conference on the Teaching of Mathematical Modelling and Applications
Contact W Blum, Universität Gesamthochschule Kassel, Fachbereich Mathematik, Heinrich-Plett-Strasse 40, D–3500 Kassel, Federal Republic of Germany.

September 8–16 (Tokyo)

46th Biennial Session of the International Statistical Institute
Contact International Statistical Institute, 428 Prinses Beatrixlaan, Voorburg, Netherlands.

September 9–11 (Louvain-la-Neuve, Belgium)

Seventh GAMM Conference on Numerical Methods in Fluid Nechanics
Contact M Deville, Unité de Mécanique Appliquée, 2 Place du Levant, B–1348 Louvain-la-Neuve, Belgium.

September 9–11 (Passau, West Germany)

Twelfth Symposium on Operations Research
Contact F. Radermacher, Lehrstuhl für Informatik und Operations Research, Universität Passau, Innstrasse 27, 8390 Passau, Federal Republic of Germany.

September 9–12 (Aachen, West Germany)

Sixth Aachen Symposium on Signal Theory: Multidimensional Signals and Image Processing
Contact D. Meyer-Ebrecht, Lehrstuhl für Messtechnik, Aachen University of Technology, 5100 Aachen, Templergraben 55, Federal Republic of Germany.

September 10–12 (Chicago)

Advances in Computational Modelling and Numerical Analysis
Contact D. Arnold, Institute for Mathematics and its Applications, Vincent Hall 514, 206 Church Street Southeast, Minneapolis, Minnesota 55455, U.S.A.

September 13–19 (Ulm, West Germany)

Journées Arithmétiques 1967
Contact E Wirsing, Universität Ulm, Abt Mathematik II, Postfach 4066, D–7900 Ulm, Federal Republic of Germany.

September 14–18 (Minneapolis, Minnesota)

Workshop on Polyhedral Combinatorics and Geometric Complexity
Contact M. Weinberger, Institute for Mathematics and its Applications, Vincent Hall 514, 206 Church Street Southeast, Minneapolis, Minnesota 55455, U.S.A.

September 17–19 (Tokyo)

First Satellite Meeting of the International Association of Statistical Computing
Contact C Hayashi, 23–11 Inokasira, 2–Tyome, Mitaka-Sei, Tokyo, Japan.

September 28–30 (Valencia, Spain)

International Conference on Linear Algebra and Applications
Contact Prof Vicente Hernandez, ETS Ing Industriales, Universidad Politécnica, Apartado 22012, 46071 Valencia, Spain.

September 29 – October 2 (Versailles, France)

Fifth International Symposium on Data Analysis and Informatics
Contact Institut National de Recherche en Informatique et en Automatique, Service des Relations Extériures, Bureau des Colloques, Domain de Voluceau, B.P. 105, 78153 Le Chesnay Cedex, France.

October 10 (Alberta, Canada)

Tenth Conference on Probability and Statistics in Atmospheric Science
Contact F Zwiers, Canadian Climate Centre, 4905 Dufferin Street, Downsview, Ontario, Canada M3H 5T4.

October 11–14 (Melbourne)

Eighth National Australian Society for Operations Research Conference
Contact Dr S Kumar, Department of Mathematics, Royal Melbourne Institute of Technology, Melbourne, Victoria, Australia.

October 12 – November 6 (Trieste, Italy)

Workshop on Mathematical Ecology
Contact ICTP, PO Box 586, 34100 Trieste, Italy.

October 19–23 (Johannesburg, S Africa)

20th International Conference on the Application of Computers and Mathematics in the Mineral Industries
Contact Conference Secretary (c31), Mintek, Private Bag X 3015, Randburg 2125, South Africa.

October 20–22 (Boston, Massachusetts)

Protext IV — Fourth International Conference on Text Processing Systems
Contact Conference Management Services, PO Box 5, 51 Sandycove Road, Dun Laoghaire, Co. Dublin, Ireland.

October 25–31 (Schwerin, E Germany)

International Conference on Population Mathematics
Contact the Secretariat ICPM 87, A Kollat, Gesellschaft für physikalische und mathematische Biologie der Deutschen Demokratischen Republik, Am Kupfergraben 7, Berlin 1080, German Democratic Republic.

October 26–30 (Beijing)

Third Asian Conference on Mathematical Logic
Contact Yang Dong-Ping, Institute of Software, Academia Sinica, PO Box 8718, Beijing, People's Republic of China.

October 26–31 (Sofia)

International Conference on Mathematical Methods in Operations Research
Contact Institute of Mathematics with Computer Centre, Bulgarian Academy of Science, 1113 Sofia, Acad G Bonchev, Block 8, Bulgaria.

November 9 – December 19 (Trieste, Italy)

College on Riemann Surfaces
Contact ICTP, PO Box 586, 34100 Trieste, Italy.

December 1–2 (Adelaide)

Second Australian Teletraffic Research Seminar
Contact L Barry, University of Adelaide, North Terrace, Adelaide, South Australia 5001, Australia.

December 14–15 (Sydney)

Competing with Computing?
Contact Dr J Franklin, School of Mathematics, University of New South Wales, Kensington, New South Wales 2033, Australia.

December 22–24 (Kurukshetra, India)

Eleventh National Systems Conference
Contact R. Arora, Convener NSC–87, Electrical Engineering Department, Regional Engineering College, Kurukshetra – 132 199 (Haryana), India.

December 26–28 (Pune, India)

Ramanujan Birth Centenary Year International Symposium on Analysis
Contact Professor NK Thakare, Department of Mathematics, University of Poona, Pune – 411 007, India.

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January 20 – February 5 (Newcastle, NSW)

28th Summer Research Institue of the Australian Mathematical Society
Contact Dr R Eggleton, Department of Mathematics, Statistics and Computer Science, University of Newcastle, Rankin Drive, Shortland, NSW 2308, Australia.

February 1–5 (Sydney)

1988 Mathematics-in-Industry Study Group
Contact Dr NG Barton, Director 1988 MISG, CSIRO Division of Mathematics and Statistics, PO Box 218, Lindfield, New South Wales 2070, Australia.

February 7–11 (Leura, NSW)

1988 Australian Applied Mathematics Conference
Contact R Grimshaw, School of Mathematics, University of New South Wales, Box 1, Kensington, New South Wales 2033, Australia.

March 14–18 (Aachen, West Germany)

Second International Conference on Hyperbolic Problems
Contact R Jeltsch, Institut für Geometrie und Praktische Mathematik, RWTH Aachen, D–5100 Aachen, Federal Republic of Germany.

April 17–30 (Banff, Canada)

First Canadian Number Theory Society Conference,
Contact R Mollin, University of Calgary, Department of Statistics, 2500 University Drive NW, Calgary, Alberta, Canada T2N 1N4.

May 16–20 (Canberra)

1988 Mathematical Sciences Congress and 32nd Annual Meeting of the Australian Mathematical Society
Contact Prof CC Heyde, Department of Statistics, Institute of Advanced Studies, Australian National University, GPO Box 4, Canberra, ACT 2601, Australia.

May 23–27 (Chiangmai, Thailand)

Conference on Mathematical Methods and Applications
Contact Prof Suwom Tangmanee, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand.

May 30 – June 3 (Singapore)

International Conference on Numerical Mathematics
Contact Secretary, International Conference on Numerical Mathematics, Department of Mathematics, National University of Singapore, Kent Ridge, Republic of Singapore 0511.

June 20–24 (Lisbon)

International Algebra Conference
Contact Centro de Algebra, Universidade de Lisboa, Rua Ernesto Vasconcelos, Bloco C1, 30 Piso, 1700 Lisboa, Portugal.

June 20–24 (Shanghai, China)

BAIL V — Fifth International Conference on oundary and Interior Layers – - Computational and Asymptotic Methods
Contact Pauline McKeever, Conference Management Services, PO Box 5, 51 Sandycove Road, Dun Laoghaire, Co. Dublin, Ireland.

June 25–30 (Xian, China)

International Conference on Biomathematics
Contact Prof Lansun Chen, Mathematical Institute, Chinese Academy of Sciences, Beijing, People's Republic of China.

July 10–16 (Manchester)

Representation Theory and Group Theory
Contact RTGT, Department of Mathematics, Institute of Science and Technology, University of Manchester, PO Box 88, Manchester M60 2QD, England.

July 13–20 (St Andrews, Scotland)

Edinburgh Mathematical Society's 1988 St Andrews Colloquium
Contact J Langley, University of St Andrews, Mathematical Institute, North Haugh, St Andrews KY16 9SS, Fife, Scotland.

July 17–27 (Swansea, Wales)

Ninth Congress of the International Association of Mathematical Physics
Contact A Truman, University College of Swansea, Department of Mathematics and Computer Science, Singleton Park, Swansea SA2 8PP, Wales.

July 18–22 (Paris)

International Association for Mathematics and Computers in Simulation: 12th World Congress on Scientific Computation
Contact the Secretary, 12th IMACS World Congress, IDN, BP 48, 59651 Villeneuve d'Ascq Cedex, France.

July 27 – August 3 (Budapest)

Sixth International Congress on Mathematical Education
Contact Dr MF Newman, Department of Mathematics, Research School of Physical Sciences, Institute of Advanced Studies, Australian National University, PO Box 4, Canberra ACT 2601, Australia.

August 8–12 (Providence, Rhode Island)

American Mathematical Society Centennial Celebration
Contact H Daly, American Mathematical Society, Meetings Department, PO Box 6248, Providence, Rhode Island 02904, U.S.A.

August 9–12 (Coleraine, N Ireland)

International Symposium in Real Analysis
Contact P Muldowney, University of Ulster, Northland Road, Londonderry BT48 7JL, Northern Ireland.

August 9–13 (Hong Kong)

First International Symposium on Algebraic Structures and Number Theory
Contact RF Turner-Smith, Department of Mathematical Studies, The Hong Kong Polytechnic, Hung Hom, Kowloon, Hong Kong.

August 12–14 (Madras, India)

International Conference on Mathematical Modelling in Sciences and Technology
Contact Prof P Achuthan, Indian Institute of Technology, Madras – 600 036, India.

August 20–26 (Pusan, Republic of Korea)

Groups — Korea 1988
Contact Prof AC Kim, Department of Mathematics, The Pusan National University, Pusan 607, Republic of Korea.

August 21–27 (Grenoble, France)

17th International Congress of Theoretical and Applied Mechanics
Contact D Caillerie, Secretary of the International Congress of Theoretical and Applied Mechanics 1988, Institut de Mécanique de Grenoble, Domain Universitaire, BP 68, 38402 Sain Martin d'Heres Cedex, France.

September 25–29 (Canberra)

Third International Conference on the Theory of Groups and Related Topics
Contact J Cossey, Mathematics Department, Faculty of Science, Australian National University, GPO Box 4, Canberra ACT 2601, Australia.

MR Carter,
Massey University.

Mathematical Visitors In New Zealand

Compiled on: 10 July 1987

The information is arranged as follows: name of visitor; home institution; whether accompanied; principal field of interest; dates of visit; principal host institution; principal contact; comments.

Definite Visits

Professor G D Anderson; Michigan State University; spouse and son; complex analysis, extremal rings and quasiconformal mappings; September 1986 — September 1987; University of Auckland; Dr M K Vamanamurthy.

Professor Charles K Chui; Texas A & M University; approximation theory, multivariate spline approximation, digital filter design; September — November 1987; University of Canterbury; Dr R K Beatson; Professor Chui is an Erskine Fellow.

Professor B F Gray; School of Chemistry, Macquarie University; mathematics of chemistry; November 1987; Massey University; Professor G C Wake.

Professor Anne Penfold Street; University of Queensland; combinatorics; September — November 1987; University of Canterbury; Dr D R Breach; Professor Penfold Street is an Erskine Fellow.

Very Likely Visits

Professor Gerald C Brown; Naval Postgraduate School, Monterey, CA; wife; large-scale mathematical programming, combinational analysis and data structures, digital operations research and numerical methods; 24–28 August 1987; Operational Research Society; Mr B R Benseman, DSIR, Applied Mathematics Division, Wellington.

Dr Grant Keady; University of Western Australia; non-linear partial differential equations; July or August 1988; Massey University; Professor G C Wake.

Dr John Nash; University of Ottawa; computational methods, management applications; January 1988 — June 1988; DSIR/AMD Mt Albert Research Centre; Dr J H Maindonald.

Notes

This listing is intended to enable workers at other institutions to invite visitors to spend time with them. Please channel invitations through the principal contact listed above.

The production of these lists and the coordination of visits depend upon my receiving information. When you have information about a visit, whether definite or not, please forward it to me as soon as you can.

Deadline for the next list: 10 October 1987, with —

Gillian Thornley,
NZMS Visitors Coordinator,
Dept of Maths and Stats,
Massey University.

Secretarial

Minutes of the Twenty-First Council Meeting

The 21–st Meeting of the Council of the NZMS was held in the Mathematics Department at the University of Waikato, and began at 10.15 on **19 May 1987.**

Present

Brian Woods (in the Chair), Derrick Breach, David Gauld, John Harper, Murray Jorgensen, Ernie Kalnins, John Shanks, Gillian Thornley, Brent Wilson, and by invitation for part of the meeting, Mark Schroder.

Apologies

On a motion from the Chair, apologies from Ivan Reilly and Marston Conder (on grounds of geography) were **received.**

Minutes of the Twentieth Council Meeting

The Chair moved that **having been circulated, these be taken as read and that they be confirmed.**

carried

Matters Arising from the Minutes

(i) Marston Conder's letter to the Minister of Education and his reply were tabled. The complaint was about the lack of representation of the NZMS on the Mathematics Syllabus Review Committee (Forms 5 to 7). The Minister, after commenting on the difficulties of keeping the committee to a workable size, wrote —

> "I am sure that broad consultation will be encouraged by the committee, that they will welcome submissions from groups such as your society, and that the syllabus review process will ensure that all points of view are considered. I believe that this consultation will work well and therefore do not intend to change the permanent composition of the Review Comittee at this stage, although I have recommended the process of co-opting extra members. If your association finds, in the future, that their voice is not heard or that the consultation process is not successful, I will reconsider the composition of this and similar committees."

(ii) BAW reported that he had written to the RSNZ about the representation of mathematics in the Fellowship of the Royal Society. A reply is awaited. BAW said that Prof. Zeeman, who supported his views, had also raised the matter with the President of the RSNZ. BAW had also talked about this to Prof. Wybourne. Perhaps mathematicians are not inclined to present themselves for membership. DG said in the past we have been too conservative in proposing people. BAW noted that among the Fellowship there is no active pure mathematician at all to make judgement on the application of the pure mathematicians. BAW will consult with Prof. Butcher, the convenor of the Physics and Maths section of RSNZ, about the process of nomination and will circulate the Council about proposals.

(iii) Letters from Prof. W. Davidson and Prof. D. Sawyer expressing their pleasure at being made honorary fellows were read.

Correspondence

The Chair moved that **the inward correspondence be received and the outward, be noted.**

carried

DRB/JAS moved that **since with increasing business the correspondence contains many routine items, these be omitted from future lists, which should name only matters of substance.**

carried

Treasurer's Report

In tabling his interim statement, JAS said that the honorary auditor had looked at the $250,000 turnover and had suggested the use of a professional auditor (estimated fee $500 – $600) in future. In the meantime, the honorary auditor wants more documentary evidence from those controlling sales of publications. It is not always easy to get information from the convenors when it was needed. The Chair moved that **the interim financial statement be received.**

carried

It was agreed that, if possible, a full audited report should be published in the August Newsletter. [Editor: it is not yet to hand.]

JAS/JFH moved that **the Society employ a professional auditor.**

carried

The firm of Peat Marwick was suggested.

The Chair moved that **the Treasurer be asked to thank the honorary auditor for his services in this and previous years, and express on behalf of all Council members their extreme gratitude.**

carried

In the discussion of the accounts, JFH asked about the Publications #1 Account. JAS replied that he and the BNZ were enquiring about the details of the transfer (which the bank may have fouled up). JFH asked about the book loss on the Australian account and was told that in closing the account, the exchange rate had been estimated before the transaction took place. JFH observed that 50% of the profits from the joint publications ventures went to the NZAMT. WBW asked if the NZAMT should be liable for any of the audit fees or for GST payments. DBG asked about the Aitken Account (established to help towards the cost of publication of Aitken's collected papers).

JAS remarked that the assets of the Society total about $80,000. BAW from the Chair expressed appreciation of the Treasurer's services. The meeting agreed with applause.

Publications

(i) Textbooks As convenor of the publications committee, GMT said a formal report will be given at the Council's October meeting. *Maths with Calculus* and *Maths with Stats* are both selling well. Currently the books are produced in a soft-cover format; perhaps, to make the books more durable, we should think about paying extra for a sewn binding.

GMT reported that Dean Halford is having trouble recovering some outstanding accounts which may have arisen through cheques being sent to the wrong place. The convenors of the publishing groups do a lot of work and Dean Halford is not able to do it for more than another year. GMT asked if a central office should be set up for the publishing operations.

The Chair moved that **between now and the next Council meeting, GMT meet with the publishing convenors at the Society's expense, to look at the possibility of centralising the publishing operations.**

carried

GMT reported that the Auckland *Calculus* has been revised (a new edition will appear next year), and that *Linear Algebra* is proceeding slowly (it is being typed up and may be ready for 1988). GMT wondered if the publications fund should be kept separate from the general funds.

WBW said that the Society should contemplate the possibility of prestige publications.

The Chair moved that **the Council thank GMT for her work.**

carried with applause

(ii) Careers in Mathematics DRB asked when this was last printed and if stocks are still available. GMT said that Prof. Wake had some copies and that there may be some at Waikato. GMT will ask Mike Carter about updating the booklet, last issued in 1980.

(iii) NZMS Information Pamphlet Members expressed appreciation of Marston Conder's work on this. DRB undertook to update the pamphlet.

(iv) Newsletter Mark Schroder, the present editor, said he had had no volunteers to take over the editorship, that it was up to the Council to exert pressure on their colleagues, and that he would continue to the end of the year if necessary, but not beyond. The Newsletter is now done on a word processor, but there is no compulsion on any successor to do it this way. DBG will try to find someone at Auckland. JAS said there should be a change from printing at University of Otago, starting with the August issue. BAW moved a vote of thanks to the Editor of the Newsletter, **carried** with acclamation.

Visitors

(i) 1987-88 List GMT is happy to continue circulating this list. The Chair conveyed the Council's appreciation.

(ii) NZMS Lecturer for 1988 JFH/DBG moved that **Professor Lee Peng Yee be invited to be the NZMS lecturer for 1988, and that Peter Lorimer be invited to be the local organiser.**

carried

(iii) Forder Lectureship and Prof. Zeeman's Visit After commenting on the great success of Prof. Zeeman's visit, BAW said he and DRB had had a long discussion with Prof. Zeeman about the terms of the Forder Lectureship, as drawn up by the London Mathematical Society. They agreed that it was better for the NZMS to give the LMS the names of those they would like to have as Forder Lecturers, rather than give a general area of interest. A strong candidate for the 1989 Lectureship has been proposed. There was much discussion on the expenses within New Zealand of a Forder Lecturer's tour. With regard to the terms of the Forder Lectureship, JFH/DBG moved that **the Council of the NZMS suggest to the LMS that in section III, 5 of the terms, the words 'full living expenses' be replaced by 'accommodation', and that everything after 'N.Z.M.S.' be deleted.**

carried

(The amended section reads: *'Accommodation and travelling expenses of the Lecturer in New Zealand during the tenure of the Lectureship shall be paid by the N.Z.M.S.'* The deleted phrase is: *'bearing in mind that the Lecturer may be accompanied by a spouse.'*)

Noting that the Council of the NZMS usually meets in May, the Chair moved that **the Council of the NZMS suggest to the LMS that in Section II.1 of the terms, the words '31st March, year x–2' be replaced with '31st May, year x–2', with possible consequential amendments to dates mentioned elsewhere in the terms.**

carried

(iv) Prof. Zeeman's Report Copies of this report to the RSNZ on Science and Mathematics in NZ and the UK had been circulated to Councillors. WBW/DRB moved that **a letter be written to Prof. Zeeman, thanking him for preparing the report and asking permission for it to be published in the NZMS Newsletter, and that the President of the RSNZ should also be asked for permission to publish the report.**

carried

(v) Other Items About Visitors MAJ commented on the success of the visits by Terry Speed and by Saunders Mac Lane as NZMS Lecturers, but wondered about the format of designating Lecturers for a particular year. Perhaps it would be better to have a general fund to be drawn on as a supplement to other funding from University departments. DBG said there was no obligation to appoint a NZMS Lecturer every year; some years we had had none, in others several. MAJ said that at present the expectation is that there should be just one NZMS Lecturer per year. Should they be expected to visit all universities? Also, more flexibility about the NZMS Visiting Lecturer programme is needed. He undertook to submit a proposal by letter to the next Council meeting. WBW expressed some disquiet about the number of Visiting Lecturers recently, and the consequent strains placed on some departments' funds.

BAW is to discuss with J. Butcher the details of possible support for an overseas visitor.

Travel Grants and Awards

(i) Student Travel Grants Within N.Z. DRB announced that since the Council meeting in October 1986, the following travel grants to graduates had been made to attend meetings in NZ —

Bau Sheng (Otago)	to Colloquium	$220,
Robert Crawford (Massey)	to Wairakei	$160,
Gerard Palmer (Massey)	to Colloquium	$160,
Aroon Parshotam (Auckland)	to Colloquium	$100,
Michael Steel (Massey)	to Colloquium	$160,
Darryn Waugh (Waikato)	to Wairakei	$160, and
Wong Siong Lie (Victoria)	to Wairakei	$180.

DRB explained that in deciding the amounts to be given, he had used distance to be travelled as a guide. The meeting considered a further aplication, and DRB/JFH moved that **Wayne Burrows (Massey) be given $160 to attend the Colloquium at the University of Waikato.**

carried

(ii) Travel Grants Overseas DRB reported that B. Calvert had been given $450 towards the costs of attending a summer school in Canberra. The Chair moved that **Andrew Pullan (Auckland) be given $500 as a student travel grant towards the cost of**

attending a conference in Canberra.

carried

The Chair moved that **Julie Falkner (Auckland) be given $500 as a student travel grant towards the cost of attending a conference in Hamburg.**

carried

GMT/WBW moved that **Margaret J. Morton (Auckland) be given $500 from the research fund towards the cost of attending a conference in Ann Arbor, Michigan.**

carried,

with DBG abstaining, on the grounds of being a sponsor for the application.

The meeting agreed that Pullan, Falkner and Morton should be asked to write reports on their trips and that these might appear in the Newsletter.

(iii) South Pacific Fund DRB announced that $850 from the Society's South Pacific Fund had been given to Dharmendra Sharma, a lecturer at USP, towards the costs of his attending two conferences in Australia and the Colloquium at Waikato. This is the first grant that has been made from the Fund. [Editor: his report appears on page 59.]

(iv) Prince and Princess of Wales Awards. JFH reported that the question of contributions towards the scheme had been raised at the RSNZ Member Bodies' Representatives' meeting, and that it was some time since the NZMS had made a contribution.

JFH/DBG moved that **the Society make a contribution of $500 to the Prince and Princess of Wales Awards fund.**

carried

(v) Hamilton Award DRB reminded the meeting that young mathematicians can be nominated for this award and indeed, some them had won it in the past. He asked members to remind their departments about it from time to time.

(vi) Suggestion from Prof. Holton A letter from Derek Holton, suggesting that the NZMS provide prizes for undergraduates in each University, was tabled. It was noted that some departments had already had such prizes and it was felt that this was an internal matter for each University to deal with. DRB undertook to write to Derek Holton about this.

(vii) Letter from Ian Collins and Others The Chair presented a letter from Ian Collins, Roger Hosking, Graeme Wake and Brian Woods, in which they pointed out that the proceedings of the Australian Applied Mathematics Conference at Wairakei included the award of the T.M. Cherry prize for the best paper by a student. They suggested that the NZMS make funds available regularly, to promote the attendance of N.Z. students at future Australian Applied Mathematics Conferences, thereby providing more Kiwi competition for the prize.

JFH suggested that the NZMS thesis competition be replaced by a prize for the best student paper given at the NZ Mathematical Colloquium. It was agreed to discuss this at the October meeting of the Council. Also, DRB is to reply to the letter, mentioning the travel grants the NZMS has awarded for students to go to Wairakei and to go overseas.

International Mathematical Olympiad

A request from Graeme Wake for funds towards the cost of sending a NZ team to the IMO was considered. The Council supported the ideas of the Olympiad, although with some reservations.

GMT/BAW moved that **the NZMS give $2000 to the organisers of the NZ team for the Mathematical Olympiad.**

DRB/JFH moved as an amendment that **the NZMS give $1000 for the year of 1987.**

The amendment was **carried** on a show of hands, 5 to 1, and the amended motion was then **carried**.

Letter from the IMU

The meeting considered a letter from the International Mathematical Union about the collection of funds for travel grants to young mathematicians from developing countries to attend the International Congress.

The Chair moved that **the Secretary forward this letter to the RSNZ with a covering letter.**

carried

Letter from ATM (UK)

The Society had received a letter from the Association of Teachers of Mathematics in the UK, which expressed concern about the possible representation of South Africa at ICME–6 in Budapest, and the NZMS was invited to give its opinions.

JFH/DRB moved that **this matter be referred to the AGM of the NZMS.**

carried

The 1998 ICM

The Secretary reported that he had been in correspondence with the secretary of the Australian Mathematical Society. The AMS was currently considering this at their AGM and DRB is awaiting a letter from them. The idea of having the 1998 ICM in the Southern Hemisphere for the first time had been well received and interest is being maintained.

DBG observed that the Australasian Congress is to be in Canberra in 1988 and that the next should be in 1991 or 1992. The venue could be Auckland or Wellington. DBG undertook to discuss this with heads of departments. The matter is to be raised again at the October meeting of the Council.

Reciprocity with the Indian Mathematical Society

In response to a letter from the IMS, EGK/DRB moved that **the Secretary, in co-operation with the Secretary of the Indian Mathematical Society, draw up a reciprocity agreement between the NZMS and the IMS.**

carried

The 1987 Colloquium

The Chair moved that **$900 be given towards the cost of running the 1987 Colloquium.**

carried

RSNZ Report

Great interest was expressed in the recently released report of the RSNZ by M. Clark and D. Vere-Jones on science and mathematics. DRB is to ask for a copy, possibly for review in the Newsletter, and to put this on the agenda for the October meeting.

Beattie Report

The NZMS has received a copy of this report; JFH reported that it was discussed at the RSNZ Member Bodies' Committee. There had been a suggestion that the RSNZ give an award for the best scientific item appearing in the media each year. JFH also observed that Professor Zeeman's report had reinforced part of the Beattie report, and he trusted that every Councillor of the NZMS had written to the Minister of Science, endorsing the report.

BAW observed that we should be more active as spokespeople on mathematics in NZ, and asked Councillors to think about publicity for mathematics in the way of news releases, and so on.

Membership

JAS reported that, excluding institutions, the membership of the NZMS was 190. It was agreed that the membership list should be published in the April 1988 issue of the Newsletter.

Other Business

(i) Honorary Membership The Chair moved that **Professor A Zulauf be offered honorary membership of the NZMS.**

carried with acclamation

(ii) Archivist's Report JFH tabled a brief report. Material relating to the Newsletter had been sent to him by M. Schroder. This included Notices published by other organisations which, with the exception of the Bulletin of the Iranian Mathematical Society, were readily available elsewhere. JFH was asked to discard these and to offer the Bull. Ir. Math. Soc. to the Library at Victoria.

The Chair moved that **although his term as Councillor was ending, JFH continue as Archivist for the NZMS.**

carried

(iii) Research Review GMT hopes to write up a report on mathematical research in N.Z. This will require liaison with the NZ Statistical Society and the NZ OR Society. Perhaps this could be raised at Council's October meeting.

(iv) Post-Graduate Topics in Maths JAS said that the current list of post-graduate topics in mathematics available at NZ Universities needs updating. He has the matter in hand.

(v) Next Meeting The next meeting of the Council of the NZMS will be held in October at the University of Canterbury.

The meeting ended at 4.05 pm.

DR Breach,
Hon Secretary.

Minutes of the Thirteenth Annual General Meeting

The Thirteenth Annual General Meeting of the New Zealand Mathematical Society was held in Room L4 at the University of Waikato, and began at 4.50 pm on **Thursday, 21 May 1987.**

Present

B.A. Woods (in the Chair), D.P. Alcorn, J. Ansell, R. Ball, D.R. Breach, J.C. Butcher, M.R. Carter, G.D. Dixit, M.J. Doherty, S.D. Forbes, D. Gauld, P. Hafner, W.D. Halford, J.F. Harper, B. Hayman, D.A. Holton, R.J. Hosking, M.A. Jorgensen, P.J. Lorimer, A. Parshotam, K.E. Pledger, D. Sharma, M. Schroder, G.J. Tee, P.J.Thomson, G.M. Thornley, C.M. Triggs, J. Turner, M.K. Vamanamurthy, G.C. Wake, W.B. Wilson, B.G. Wybourne.

Apologies

M.D.E. Conder, R.I. Goldblatt, G. Olive, I.L. Reilly, J.A. Shanks tendered their apologies. J. Harper and D. Holton moved that **the apologies be sustained.**

The motion was **carried.**

Minutes of the Previous AGM

The Chair moved that **the Minutes of the Twelfth Annual General Meeting of the NZMS, as circulated in the Newsletter, be taken as read, and confirmed.**

The motion was **carried.**

Matters Arising from the Minutes

G. Tee asked if the suggested meeting between the Forder Lecturer, Professor Zeeman, and the Ministers of Education and Science, had taken place. The Acting President, B.A. Woods, replied that the meeting had taken place and that Professor Zeeman had written a report to the Royal Society of New Zealand on Science in NZ and the UK, but this had not yet been made available to the public.

Acting President's Report

In his report, the Acting President said that during the past year, the Society had given financial support to the Colloquium, the Australian Mathematical Society's Applied Mathematics Conference at Wairakei and the Australasian Combinatorial Mathematics Society's Conference in Dunedin. Travel grants had been given to 10 students and two university staff members, and the first grant from the South Pacific Fund had been made, to help a mathematician from Fiji to attend conferences in Australia and the Colloquium in New Zealand. Tours by two NZMS Lecturers, Terry Speed and Saunders Mac Lane, had been promoted. The Society had also contributed towards the visit of Christopher Zeeman, the first Forder Lecturer. During his visit, Professor Zeeman had met with the Ministers of Education and Science and had submitted a report on science and mathematics to the Royal Society of New Zealand. Professor Zeeman had also had a discussion with the Acting President and the Secretary about the terms of the Forder Lectureship.

Treasurer's Report

As the Treasurer had had to return to Dunedin, his report was presented by the Chair. Because of the success of the Society's publications scheme, there had been a turn-over of nearly a quarter of a million dollars, and a rapid increase in the complexity of transactions meant that the Society would have to employ professional auditors. The expenditure statement and balance sheet for 1986 were both interim, as the audit was not yet complete. The Society's finances were in a healthy condition, with assets of about $85,000 if stocks of unsold textbooks were included. The Chair moved that **the report be adopted.** J. Ansell and G. Wake moved as an amendment that **the report be adopted subject to the receipt of a satisfactory**

auditor's report. The amendment and
the amended motion were both **carried.**

It was agreed that the audited report should be published in the August Newsletter, if possible. [Editor's note — it has not yet arrived.]

W.B. Wilson and D. Holton moved that **the Society express its gratitude to the Treasurer, John Shanks, for the amount of work he puts into looking after the Society's finances.**

The motion was **carried** with spontaneous acclamation.

J. Turner and G. Wake moved that **the Society show its appreciation of the source of the Society's financial well-being, by giving great thanks to the writers and distributors of the text-books and to the publications convenors.**

The motion was **carried** with joyous applause.

Election of Council Members

The Chair announced that there were three nominations for the three vacancies on the Council. There being no further nominations, **R.I. Goldblatt, A. Sneyd and C. Triggs were declared elected to the Council, each for a term of three years commencing June 1987.**

Applause.

W.B. Wilson and D. Breach moved that **the Society express its thanks to the retiring members of the Council.**

The motion was **carried** with acclamation.

Annual Subscription

On the recommendation of the Treasurer, the Chair suggested that the annual subscription remain at $23.50 including G.S.T. M. Schroder and P. Thomson moved that **the annual subscription should be $30.00 including G.S.T.**

The motion was **carried** on a show of hands by 14 to 8.

During the long debate on this motion, the following points were raised: that the healthy state of the Society's finances did not warrant an increase; that in spite of the healthy state of the finances, provision must be made for contingencies; that an increased subscription would discourage many from joining the Society; that for a more active Mathematical Society, higher fees were necessary to cover operations; that putting up prices encourages inflation; that due to inflation, increases in the subscription were necessary; that it is not the Society's function to make large profits; that the Society should not be squeamish about enjoying a good income. In addition, some suggested that it might be wise to keep the publications accounts separately. There was also the possibility of having to employ aid, to help with the Treasurer's and Secretary's work.

J. Harper and W.B. Wilson moved that **there be a discount of $2.00 for prompt payment.**

The motion was **carried.**

J. Harper and G. Wake moved that **the incoming Council explore the possibilites of reciprocal arrangements withh the N.Z. Mathematical Associations.**

The motion was **carried.**

Letter from ATM (UK)

A letter to the Secretary from the Association of Teachers of Mathematics, in the UK, was referred to the meeting by Council. Copies of this circular letter had been sent to a number of scientific bodies in the UK and to 51 national Mathematical Associations throughout the world. It begins by stating that the General Council of the ATM (UK) has become increasingly concerned with possible South African representaiton at ICME–6 to be held in Budapest. The letter continues:

> "We recognise that a real moral dilemma is involved. The choice between the policy of the International Council of Scientific Unions (ICSU) and the kind of boycotting action undertaken at the World Archaeological Congress is not a choice between good and bad but between two alternative and morally defensible stances." . . . "We would be very grateful to hear your views or the views of your Association."

J. Butcher and R. Hosking moved that **the letter be referred to the Royal Society of New Zealand and that a copy be sent to the National Committee on Mathematics.**

In speaking to his motion, J. Butcher said that the NZMS does not communicate directly with ICME and that such things were dealt with at the international level through the RSNZ and its National Committee on Mathematics. R. Hosking said that the RSNZ is the cornerstone of national scientific representation in New Zealand. B. Wybourne, recently returned from a meeting in Switzerland, strongly backed the ICSU policy. S. Forbes said the ATM were asking for our views and wanted the views of many societies. J. Harper said that for the RSNZ, the views of a member body would be helpful.

The motion was **carried.**

The Chair then raised the question of views to be communicated. R. Hosking said that it should be strongly endorsed that the RSNZ adhere to the ICSU resolution, which he paraphrased as 'science is science and politics is politics and scientists should be free to go anywhere to exchange their ideas with others'.

M. Carter and S. Forbes moved that **the NZMS supports the ICSU policy on participation in scientific conferences.**

After a debate in which the two stances mentioned in the ATM letter were both strongly supported, S. Forbes **withdrew as seconder** of the motion. J. Harper then said that he would **second the motion.** Then D. Holton moved that **the motion now be put.** This procedural motion was **carried**, and the motion under debate was then put and

lost on a show of hands 8 to 13.

J. Butcher suggested moving to the next item of the Agenda. Before doing this, the Acting President undertook to write to the Chairperson of the ATM, giving an outline of the division. B. Wybourne suggested that the NZMS obtain a copy of the RSNZ's bluebook on conferences.

Other Business

(i) R. Hosking said that greater student participation in Colloquium meetings should be encouraged and commended this matter to the Council.

(ii) J. Harper said that at the Council meeting, he had suggested that the thesis prize be replaced by a prize for the best paper presented by a student.

(iii) G. Wake said that the Problems and Queries section in the Newsletter was evoking a poor response, but he would let it run until the end of the year.

(iv) G. Wake asked the incoming Council to update the booklet *Careers in Mathematics*, last issued in 1980.

(v) P. Lorimer remarked that *Maths with Calculus* has made a profit of $23,000 so far. Finding it a difficult book to use, apparently hastily thrown together, he asked: should not some of the $23,000 be used to pay people to produce the book professionally? In reply, S. Forbes said that she found it to be a an excellent book to teach from and had not heard criticism of it from others. G. Wake concurred. J. Butcher said that the money should be used to help mathematical education at the secondary level in NZ and that the Council should look into ways of doing this.

(vi) P. Thomson gave notice of a future meeting of ICOTS at the University of Otago, for which funds may be hard to obtain. He asked if the NZMS would think of making a contribution. The Chair suggested that ICOTS should apply to the Council at the appropriate time.

(vii) D. Holton and G. Wake moved that **the President of the Society be requested to send a letter to the Minister of Education, expressing concern about the state of mathematics in the NZ educational system.**

The motion was **carried**.

(viii) M. Schroder said that the local expenses of NZMS Visiting Lecturers could make a heavy demand on a mathematics department, and asked that ways of avoiding this be looked into.

There being no further business, the meeting closed at 6.25 p.m.

DR Breach,
Hon Secretary,
25 May 1987.

Minutes of a Brief Meeting of the Council

The Council held a brief meeting immediately after the Annual General Meeting, on Thursday, 21 May 1987.

It was moved and **carried** that the following be appointed as Officers and Representatives of the Society: ... [Editor: see the Notice on page 3 of this issue.]

The meeting ended at 6.30 pm.

DR Breach,
Hon Secretary.

I M O Problems

Given that we are planning to take a team of six students to Canberra for the International Mathematical Olympiad in 1988, we will also need to take some Olympiad-type problems.

Would anyone interested in inventing such problems please contact me as soon as possible. I am trying to get a small group together, with the aim of having some problems by early next year.

Derek Holton,
University of Otago.

Problems and Queries

Summary

P1 The infinite sequence — solution published December 1986.

P2 Mean value theorem in the complex plane — solution published April 1987.

P3 The Hendy graphs — partial solution received — any more?

P4 Dimensionless ratios — still unsolved.

P5 Factorisation of a function of many variables — solution published below.

P6 Recurrence relation and Fibonacci numbers — solution published below.

P7 A bowling problem — still unsolved.

P8 Squares in triangles — new problem.

Q1 Teaching topics for elementary discrete maths for computer science — raised August 1986 — no replies yet. [Editor: there are many provocative thoughts and good ideas in *The Future of College Mathematics*, *New Directions in Applied Mathematics*, and *New Directions in College Mathematics*, all published by Springer under various editors.]

We would love to hear about your favourite **P/Q**. A big thankyou to those who sent in solutions to part or all of **P5** and **P6** — David Hill, Ted Zulauf, Terry Moore and Mike Carter.

M Hendy and G Wake,
PQ Editors,
Massey University.

Problem P8 *from T Moore, Massey University —*

Find the square of maximal area which fits inside a given triangle.

Solution P5 *from T Moore and MR Carter, Massey University, to the*

Problem from T Moore:

It is often necessary to factorise a function of several variables. It is also often necessary, for some functions, to show that such a factorisation is impossible.

1 Find a necessary and sufficient condition for a function $f(x, y)$ to factorise in the form $f(x, y) = ag(x)h(y)$.

2 Generalise this to functions of n variables.

3 Find a necessary and sufficient condition for a function of two variables to be expressible in the form

$$f(x, y) = a(x) + b(y) + c(x)d(y).$$

4 Generalise this to a function of n variables.

For 1 and 2: First, we show how item 1 was discovered, then we give a precise proof of 2. The idea is that if $f(x, y)$ factorises, then for any fixed $\bar{y}$, the fraction $f(x, y)/f(x, \bar{y})$ depends on y alone, independent of x. Thus for any fixed $\bar{x}$,

$$\frac{f(x, y)}{f(x, \bar{y})} = \frac{f(\bar{x}, y)}{f(\bar{x}, \bar{y})},$$

for all x and y. This immediately gives a factorisation, but requires $f(x, \bar{y}) \neq 0$ for all x.

To apply this to functions of n variables, note that the factorisation was obtained from the condition because $f(x, \bar{y})$ and $f(\bar{x}, y)$ depend on only one variable. Now suppose that $f = f(x_1, \ldots x_n)$ is not identically zero (if it were, the factorisation would be trivial). Let $(\bar{x}_1, \ldots \bar{x}_n)$ be such that $\bar{f} = f(\bar{x}_1, \ldots \bar{x}_n) \neq 0$ and let $\bar{f}_i$ be obtained from $\bar{f}$ by substituting x_i for $\bar{x}_i$. Now if f factorises, then $\bar{f}_1 \bar{f}_2 \ldots \bar{f}_n = f\,(\bar{f})^{n-1}$. This condition is also sufficient, because it immediately gives a factorisation.

Note that as this result applies in any group, it gives a necessary and sufficient condition for decomposibility as a sum.

For 3: For fixed x', y', let $g(x, y) = f(x, y) - f(x', y) + f(x', y') - f(x, y')$. If $f(x, y)$ is expressible in the required form, then

$$g(x, y) = \{c(x) - c(x')\}\,\{d(x) - d(x')\},$$

after a little algebra. As above, take $\bar{x}$, $\bar{y}$ so that $g(\bar{x}, \bar{y}) \neq 0$, and obtain the necessary and sufficient condition $g(x, y)\,g(\bar{x}, \bar{y}) = g(x, \bar{y})\,g(\bar{x}, y)$. Clearly this solves the original problem.

For 4: Of the many possible generalisations of the result in part 3, we wanted necessary and sufficient conditions for $f(x_1, \ldots x_n) = \sum a_i(x_i) + \prod c_i(x_i)$. So far, we have been unable to find such a condition. But note that the previous results apply to functions from any set, and so for any fixed i, we can treat x_i as one variable, and the rest as a vector. Thus we can apply the method of **3** separately to each component. Unfortunately, as the decomposition in **3** is not unique, when one applies the method of **2** to the sum and product terms, one gets a sufficient condition that need not be necessary.

Solution P6 *from David Hill (Otago), A Zulauf (Waikato) and others, to the*

> *Problem from Trevor Boyle, Assessment Unit, Department of Education, and Mike Hendy, Massey:*
> A recurrence relation (A_n) is defined by: $A_0 = 0$, $A_1 = 2$ and $A_{n+2} = A_n + A_{n+1} + 1$, for all other positive integers n. Prove or disprove the following statements:
>
> (i) for $n > 1$, $A_n \equiv 0$ modulo n iff n is prime, and
>
> (ii) for p an odd prime, if $n \equiv 1$ or $n \equiv p$ modulo m_p, then $A_n \equiv 0$ modulo p, where
>
> $$m_p = \begin{cases} p - 1, & \text{if } p \equiv 1,\ 5, \text{ or } 9 \text{ modulo } 10; \\ 2p + 2, & \text{if } p \equiv 3 \text{ or } 7 \text{ modulo } 10. \end{cases}$$

David Hill notes the connection of our A_n with the Lucas numbers (v_n), namely,

$$A_{n+1} = v_n = \alpha^n + \beta^n - 1 = \sum_{1 \le k \le n/2} (\tfrac{n}{k}) \binom{n-1-k}{k-1},$$

where $\alpha = (1+\sqrt{5})/2$ and $\beta = (1-\sqrt{5})/2$, and suggests the 'only if' part of (i) is false, the smallest composite n with $A_n \equiv 0$ modulo n being 705. Mu math (at M.U., naturally) gives us

A_{705} = 2 169 133 972 532 938 006 110 694 904 080 729 167 368 737 086 736 963 884 235 248 637 362 562 310 877 666 927 155 150 078 519 441 454 973 795 318 130 267 004 238 028 943 442 676 926 535 761 270 635,

which is clearly a multiple of 705, namely,

A_{705} = 705 × 3 076 785 776 642 465 256 894 602 700 823 729 315 416 648 349 981 509 055 652 834 946 613 563 561 528 605 570 432 836 990 807 718 375 849 355 061 177 683 693 954 650 983 606 633 938 348 597 547.

A Zulauf (Waikato) looks after the rest of the problem, that is, the 'if' part of (i) and all of (ii), by connecting the A_n to the Fibonacci numbers:

Let the sequence (A_n) be extended to $-\infty$ by defining $A_1 = 0$ and $A_2 = 2$ as before, and

$$A_n = A_{n-2} + A_{n-1} + 1 = A_{n+2} - A_{n+1} - 1. \tag{0}$$

Let P be the set of all primes $\equiv \pm 1$ modulo 5 and Q be the set of all odd primes $\equiv \pm 2$ modulo 5. Let $m_2 = 3$, $m_5 = 4$, $m_p = p-1$ if $p \in P$, and $m_p = 2p+2$ if $p \in Q$. We shall prove that $A_n \equiv 0$ modulo p in the following cases:

(a) $n \equiv 1$ modulo m_p if $p \in P$ or $p = 5$, or

(b) $n \equiv 1$ or $n \equiv p$ modulo m_p if $p \in Q$ or $p = 2$.

Let the Fibonacci sequence (U_n) be extended to all integers by defining

$$U_1 = U_2 = 1, \quad \text{and} \quad U_n = U_{n-2} + U_{n-1} = U_{n+2} - U_{n+1}. \tag{1}$$

By an easy induction,

$$A_n = U_{n+1} + U_{n-1} - 1 \tag{2}$$

for all integers n. Now 'everyone knows' [see Hardy and Wright's *Introduction to the Theory of Numbers* if — like the Editor — you are not everyone], that if $p \in P$ then

$$U_{p-1} \equiv 1 = U_{-1} \quad \text{modulo } p \quad \text{and} \quad U_p \equiv 0 = U_0 \quad \text{modulo } p,$$

from which it easily follows by (1) that, modulo p, the sequence (U_n) is periodic with period $U_{-1}, U_0, U_1, \ldots, U_{p-2}$.

Similarly, if $p \in Q$,

$$U_p \equiv -1 = -U_{-1} \quad \text{modulo } p \quad \text{and} \quad U_{p+1} \equiv 0 = -U_0 \quad \text{modulo } p,$$

from which it follows that, modulo p, the sequence (U_n) is periodic with period $U_{-1}, U_0, U_n, \ldots, U_{p-1}, -U_{-1}, -U_0, \ldots, -U_{p-n}$. We deduce by (2) that, modulo p, the sequence (A_n) is periodic with a period of length m_p if $p \in P$ or $p \in Q$. Further, one can verify directly that the same is true if $p = 2$ or $p = 5$.

Hence, for all primes p, and for all integers n and r,

$$A_n \equiv A_r \quad \text{modulo } p \quad \text{if} \quad n \equiv r \quad \text{modulo } m_p. \tag{3}$$

Finally, $A_1 = 0$, and

$$\text{if} \quad p = 2, \quad \text{then} \quad A_p = A_2 = 2 \equiv 0 \quad \text{modulo } p, \quad \text{and}$$

$$\text{if} \quad p \in Q, \quad \text{then} \quad A_p = U_{p+1} + U_{p-1} - 1 = 2U_{p+1} - U_p - 1 \equiv 0 \quad \text{modulo } p.$$

By (3), this concludes the proof of assertions (a) and (b).

Saunders Mac Lane: Impressions of an Interview

M Schroder

In February, Saunders Mac Lane's visit drew me to Dunedin, and at Gloria Olive's urging, I 'interviewed' him. As I did so without shorthand or microphone, the outcome is biased not only by my choice of topics, but also by that amnestic functor inherent in any working mathematician — namely, memory. If I got his opinions wrong, I am deeply sorry.

Changes? In the U.S., mathematicians gradually moved away from their colleagues in other disciplines, a trend now in reverse.

National Styles? What styles? ... Though the Hungarians may have developed a distinctive style of doing math, I can see little evidence for this among other nationalities.

New Maths? When the S.M.S.G. was developing a revised school syllabus in the 50's, it made a point of involving school principals and Teachers College instructors, but it got very little input from 'professional pedagogues'. At its insistence, Training Institutes were set up all across the country, to provide term, semester or year 'conversion courses' for math teachers.

Degrees in Maths Education? On the whole, Departments of Math Education have very little contact with Math Departments or math instructors (and maybe, little contact with Education Departments either). Math students and staff tend to look down on degrees and programmes in Math Education, compared with similar math degrees. In general, math instructors and professors have (had) no contact with educational theory, the psychology of learning, or the like. (Nevertheless, they seldom hesitate to vent their opinions on these matters ...)

Remedial Maths? I've had no contact with any of these programmes.

Journals and Communication? As the cost of journals and books continues to rise, institutions as well as individuals are forced to cancel and cut back. This makes it harder for anyone to keep in touch with current research: pre-printing helps overcome this — but only for those lucky enough to be 'on the circulation list', or close enough to 'the grape-vine'. It also beats the 'back-log' problem of many journals.

As the tide of print ebbs away from more mathematicians, conferences, travel, visits, exchanges and leave all play an increasingly important part in reducing their isolation. So do Math Reviews and Zentralblatt ... I'm proud to say, I was an inaugural subscriber to M.R. However, I can't comment on electronic mail, publishing or searches, as I haven't had to use them yet ...

Attitudes to Maths? The Notices document a real shift in mathematicians' attitudes and in their view of their place in the world at large: involvement in applications, in influencing government and industry, and once again, in schools and teacher education. Further, mathematicians need to do a better job in educating the lay public: they should give talks and public lectures, produce radio and television programmes, generate interest among children outside schools as well as inside, with puzzles, games and even some 'real' math. Of course, this sort of publicity campaign is foreign to most mathematicians!

Can Maths Societies Help? Pass.

Sponsored Research? In the U.S. (except for the D.A.R.P.A. and for the classified research done during World War II), agencies and sponsors consider the proposals put forward by investigators, rather than 'putting a job out for contract'. In general, these agencies place NO restrictions on publication: thus the mathematical community guides itself, very much according to its own priorities. However, some sponsors do seem to get 'poor value for money'.

Prime Number Cryptography? In this case, fortunately rare, the prohibition on publishing was by no means as clear-cut or wide-spread as some reports indicated.

Pure Research? Society does benefit from this, but indirectly, through the creation and maintenance of a competent and expert mathematical community.

Unlike most mathematicians, you have changed your field several times. What made you do this, and how did you get over the 'bridging period'?

In fact, the transitions were smooth and fairly natural, eased by a broad and good undergraduate degree (in set theory, point set topology, complex variables, mechanics and so on).

My 'logic' period at Göttingen can now be seen as a premature atttempt to invent proof theory.

After that, the year or two from 1934 saw me return to algebra, to valuations in particular, because in my first real job, at Harvard, I offered logic or algebra — and they took the latter. This led to my collaboration with Schilling and then to my interest in crossed products. These took me into algebraic topology ... Eilenberg ... a transition eased by Hassler Whitney's presence. Finally, my work in homological algebra developed naturally into category theory.

But — all my interests remained active, even mechanics*.

I developed an interest in groups at Chicago, but did not follow it up as I was Chairman at the time. Anyway, I 'did not feel suited' to groups, and there were 'better people' around; John Thompson was just starting (under my supervision, in fact).

In short, all the shifts occurred naturally with the development of my work, and so I never needed any 'bridging period'.

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* The list of publications given in his 'Selected Works' (Springer, 1979) confirms this. That book also gives an interesting biographical sketch. — M. S.

Saunders Mac Lane in Dunedin

Photo by courtesy of the Otago Daily Times